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CYPRIPEDIUMS:—

1, INSIGNE, VAR. 2, CHAMBERLAINIANUM. 3, EVENOR.

CYPRIPEDIUMS

No genus or race of Orchids that has been brought under cultivation has yielded so readily, and we may add, so strikingly, to its influence as *Cypripedium*. This is not only apparent in the results of hybridization, but also in the species themselves, especially in those that have been longest under the cultivator's care. The most obvious effects of cultural influence have been the development of more robust foliage of a brighter colour; the normally one-flowered scape occasionally becomes two-flowered; the flowers are often larger and modified in colour (Veitch). Generally they are easily cultivated, they flower freely and may readily be induced to mature seeds from which plants can be raised. The species, with few exceptions, readily intercross, and consequently an enormous number of hybrids have been raised artificially. Two of the three represented in the plate are true species, the third, *EVENOR*, is a garden hybrid. Recently the genus has been divided by botanists into four, viz.:—*Cypripedium*, *Phragmopedilum*, *Paphiopedilum*, and *Selenipedium*.

THE GARDENER'S ASSISTANT

A PRACTICAL AND SCIENTIFIC EXPOSITION OF THE
ART OF GARDENING IN ALL ITS BRANCHES

BY

ROBERT THOMPSON

OF THE ROYAL HORTICULTURAL SOCIETY'S GARDENS, CHISWICK

NEW EDITION

REVISED AND ENTIRELY REMODELLED UNDER THE DIRECTION
AND GENERAL EDITORSHIP OF

WILLIAM WATSON

CURATOR, ROYAL GARDENS, KEW

WITH CONTRIBUTIONS FROM

DR. M. T. MASTERS, F.R.S., EDWARD MAWLEY, F.M.S., G. MASSEE, F.L.S.

F. W. BURBIDGE, M.A., F.L.S., J. FRASER, F.L.S., J. J. WILLIS

R. LEWIS CASTLE, W. IGGULDEN, R. DEAN, J. HUDSON, J. DOUGLAS, W. J. BEAN

AND NUMEROUS OTHER EMINENT SPECIALISTS

ILLUSTRATED BY NUMEROUS ENGRAVINGS IN THE TEXT,
AND A SERIES OF PLATES IN COLOUR, AND OF PLATES IN BLACK-AND-WHITE

Divisional-Vol. I

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PREFACE

The original edition of the well-known *Gardener's Assistant* was issued in 1859, under the editorship of the late Mr. Robert Thompson, Superintendent of the Royal Horticultural Society's Gardens at Chiswick, an eminent authority on all matters appertaining to English horticulture. He was assisted by Mr. William Paul, Mr. Cock, Mr. Salter, and Mr. Glendenning, who contributed chapters on the subjects of which they were leading practical exponents. The work was at once welcomed as "*the soundest and best guide to practical gardening that has been published in our times*", "*the best book on general practical horticulture in the English language*", &c.

In 1877, and again in 1884, the work was thoroughly revised and enlarged by Mr. Thomas Moore, F.L.S., Curator of the Chelsea Botanic Gardens, and one of the most thorough and critical of horticulturists. He was assisted by numerous specialists, including Messrs. W. B. Hemsley, J. C. Niven, F. W. Burbidge, T. Baines, R. Dean, and J. Douglas. The new issue was received with even greater favour than the previous one. Mr. William Tillery, Gardener to His Grace the Duke of Portland, Welbeck, one of the cleverest of English gardeners, wrote concerning it: "I consider this new edition of Thompson's *Gardener's Assistant* the most complete work on horticulture and floriculture that has ever been published. Every gardener should have a copy of it, both for its practical and scientific interest, and as a guide to all the duties of the profession." *The Athenæum* described it as "*A veritable encyclopedia to which all may turn who wish to have the best and soundest information on the practice of gardening*".

The work has again been entirely remodelled and rearranged for a New Edition, so as to render it thoroughly comprehensive and in keeping with the gardening spirit of the day. The alterations and additions are so numerous that this new edition is practically a new book, in which every department of the garden is exhaustively dealt with.

The new edition was commenced under the joint general editorship of Mr. Edward W. Badger and Mr. A. F. Barron. Owing to failing health these gentlemen were, however, compelled to relinquish the task, not, however, before some progress had been made and the services of specialists enlisted. The duties of general editor were then entrusted to Mr. William Watson, Curator, Royal Gardens, Kew, an experienced practical horticulturist and author, under whose supervision the work has been carried to completion in such a manner as to assure that the *Gardener's Assistant*

will continue to hold its high place as the standard work on the science and practice of horticulture.

Horticultural art has made such progress in recent years that a work of the comprehensive character of the present one could only be produced by the co-operation of many specialists. The assistance of some of the most eminent horticulturists and others has therefore been obtained. The following is a list of the contributors and the initials appended to the particular chapters which they have written or revised.

A. H.	A. HEMSLEY.	J. J. W.	J. J. WILLIS.
A. P.	ARCHIBALD PIPER.	J. M.	J. MILES.
A. W.	A. WARD.	J. M'L.	J. M'INDOE.
E. B.	EDWIN BECKETT.	J. O'B.	JAMES O'BRIEN.
E. M.	EDWARD F. R. MAWLEY, F.R.Met.Soc.	J. S.	J. SMITH.
F. M.	FREDERICK MOORE.	M. D.	MALCOLM DUNN.
F. W. B.	F. W. BURBIDGE, M.A., F.L.S.	M. T. M.	DR. MAXWELL T. MASTERS, F.R.S.
G. M.	G. MASSEE, F.L.S.	R. D.	RICHARD DEAN.
G. T. M.	G. T. MILES.	R. L. C.	R. LEWIS CASTLE.
H. C. P.	H. C. PRINSEP.	W. C.	W. CRUMP.
J. B.	JAMES BOYD.	W. D.	W. DALLIMORE.
J. D.	JAMES DOUGLAS.	W. H. D.	W. H. DIVERS.
J. F.	JOHN FRASER, F.L.S.	W. I.	W. IGGULDEN.
J. H.	JAMES HUDSON.	W. J. B.	W. J. BEAN.
		W. S.	W. SPINKS.

For those chapters which are not initialled the editor is responsible, though he has, wherever necessary, made use of expert knowledge.

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THE GARDENER'S ASSISTANT

INTRODUCTORY

CALENDAR OF OPERATIONS IN THE FLOWER-GARDEN

It is necessary to observe, that no calendrical directions can be made to justify the expectation that they can be strictly followed in all cases. The climate of the locality, the season, soil, and other circumstances, may render deviation expedient or absolutely necessary. It will be found, however, that in preparing the following Calendar most of the circumstances that lead to exceptions have been noticed, and suitable directions given accordingly. It is obviously impossible to provide for every contingency; but any intelligent person will easily adopt such modifications as his particular case may require. On the whole, it is presumed that the following Calendar will be generally applicable throughout the United Kingdom. It may be said that over this extent the climate is exceedingly variable, and therefore no one Calendar can be applicable; but within certain limits of elevation the difference between the temperatures of any two places is much less than frequently occurs between the temperatures of two different seasons at the same place. For example, if we take March—the principal spring month for seed-sowing—we find that over nearly ten degrees of latitude, extending from Paris to Wick, in Caithness, the mean temperature of that month differs very little on the average of a number of years, as will be seen by the following table:—

	Latitude.	Mean Temperature of March.
Paris, ...	48° 50'	43·79
Rouen, ...	49 26	41·12
Brussels, ...	50 51	42·78
Chiswick, London, ...	51 29	42·23
Boston, Lincolnshire, ...	52 48	41·67
Dublin, ...	53 21	42·46
Liverpool, ...	53 25	44·44
Edinburgh, ...	55 58	40·53
Dundee, ...	56 27	42·20
Aberdeen, ...	57 9	42·80
Elgin, Morayshire, ...	57 38	40·53
Wick, Caithnessshire, ...	58 29	41·94

From the above it appears that the mean temperature of March is nearly the same at London, Dublin, Dundee, and Aberdeen, although the last-named of these places is nearly 400 miles north of the first. At Elgin, the month of March is just as warm as it is at Edinburgh; and at Wick, furthest north of the towns noted, the mean temperature at that period of the year is higher than at Edinburgh. It will also be seen that at all the above places the difference of temperature in March is not such as to materially affect the CALENDAR OF OPERATIONS. In fact its scope may include all those widely-distant places.

But in different seasons, at the same place, a greater variation than that arising from latitude frequently occurs, in consequence of which considerable modifications of usually applicable directions have to be made. The mean temperature of the month to which we have referred varies as much as ten degrees in different years; and operations such as sowing and planting, which in ordinary seasons would be properly done in the first week of March, may not be at all practicable, in consequence of frost and snow, till the very end of the month.

The adaptation of a Calendar, therefore, is more affected by the variations of the seasons than by any circumstance connected with localities fit for gardens throughout the extent of Britain. If, then, a Calendar is carefully made for one place, it may be considered suitable for this country in general. By gardeners in the south, as well as in the north, calendrical directions must be understood with the proviso—*weather and state of the soil permitting*. If these are favourable the earliest practicable opportunity should be taken to carry out the operations indicated.

JANUARY.

PLANT-HOUSES.

Orchid Houses.—All through this month it will be very necessary to pay special attention to orchids, as there are some species which do not thrive under artificial heat if it be too liberally supplied; while at the same time some of those from the hotter regions of the earth would suffer in a low moist temperature if allowed to remain under those conditions for any protracted period. *Odontoglossums* of the *crispum* type should be kept in a temperature of from 45° at night to 50° or 60° in the day, according to the weather. Air should be admitted on all favourable occasions, and the plants should be sprinkled with a syringe every day that the weather permits. If possible, the house should be washed and thoroughly cleaned inside, so as to get rid of all insect and other pests that may have crept inside from the cold. Constant supervision must be exercised to prevent snails from destroying the flower-spikes, which they soon find out if any are showing.—Those of the *vexillarium* type ought to be kept in a temperature a few degrees higher; also *O. Harryanum*, *O. citrosmum*, *O. Roezlii*, and others. If the weather in this month be very severe, so that much fire-heat is necessary to keep the temperature to the requisite degree, a close search must be made for thrips. A little sulphur put down the sheaths will be sufficient to keep them in check. *Some of the different sections of *Dendrobiums* will now be in flower, and they should be kept free from damp or the flowers will become spotted. Those of the nobile division, as, for example, *Ainsworthii*, *aureum*, and *moniliforme*, may have a temperature of from 50° to 55° Fahr. when in flower, and, while at rest, from 45° to 50°, according to the weather. Plants belonging to the *bigibbum* section should be kept in a temperature which should not fall below 60°; neither ought such as *Farmeri* to be subjected to a lower temperature. *Cattleyas* generally will now be at rest, and they should have a temperature of from 55° to 60°, with a rather dry atmosphere. Those who grow a mixed collection of orchids in one house will find the *Zygopetalums* very useful at this period of the year. These thrive best in an intermediate temperature. Most of the *Calanthes* will by this time have finished flowering, and should therefore be put to rest in a warm dry place, which should not be allowed to fall below 55°. As many of the *Oncidiums* will be throwing

up their flower-spikes, they will require careful watching to prevent slugs from eating them.

Hothouse.—During the present month work in this department is not abnormally severe. Special care, however, must be taken to keep the houses at the proper temperature, for as the inmates of these structures have their native habitats in warm countries, they will not remain in health if subjected to cold. Where much house decoration is required it will be requisite to propagate plants for the purpose, and to bring them forward, so that they may take the place of those which become unhealthy through standing too long in dwelling-rooms.

Caladium bulbs may be divided where there is sufficient heat at command to cause them to commence growth quickly. The little *Argyrites* and *Le Nain Rouge* are two useful kinds for this purpose. Small palms should be potted on, so that they may be well rooted before being removed. *Kentias*, *Cocos*, *Arecas*, and *Geonomas* are the most easily adapted to this use. Such plants as *Gymnostachyum*, *Acalyphas*, *Pandanus*, *Panicum*, *Asparagus plumosus*, *Cyperus*, *Crotons*, and the like, are all useful in a small state, and may be propagated where sufficient heat is available. Many of the plants in this department will soon be starting into growth, and will therefore require re-potting. Material for this, such as peat loam, leaf-mould, sand, cocoa-nut fibre, manure, and moss, should be got ready, and, if possible, put into a warm place, so that it may be of the same temperature as that in which the plants are growing. Have all pots and drainage material washed previous to using them, as cleanliness is of great importance in plant-cultivation.

Intermediate House.—This will now be occupied with the preparation of cut flowers and plants for the conservatory, for where a supply of these has to be kept up it is imperative that they should be subjected to a lower degree of heat than that of the forcing house before they are removed to cooler structures. *Bouvardias*, *Heliotropes*, and many other plants of a similar nature will grow in such places. *Imantophyllums*, *Amaryllis*, and *Epiphyllums*, together with many other plants of a like nature, will succeed well in a temperature of about 55° Fahr., in addition to those which have been brought from warmer houses to be hardened a little before removal to a lower temperature.

Forcing House.—Where a constant demand for flowering plants exists many things will have to be brought forward in heat. Among these may be mentioned *Azalea mollis*, *A. indica*, *A. pontica*,

and the various Ghent varieties. These, with *Spiræas*, including *Spiræa astilboides*, *S. japonica*, *S. confusa*, and *S. Thunbergii*, Lilacs, Philadelphus, Deutzias, Rhododendrons, and Roses, should be potted up, and introduced in batches as they are required. Tuberoses will also have arrived by this time, and a batch of them ought to be started in small pots, potting them on into those of larger size as soon as they show their flower-spikes. Batches of *Lilium Harrisii*, Hyacinths, Tulips, Lily of the Valley, Polygonatum, Narcissus, Gladiolus (The Bride), and other bulbs ought also to be brought forward in gentle heat, and removed, just as the flowers begin to expand, into a cooler and more airy structure. This is done in order that their flowers may be of greater substance, and therefore better able to endure the lower temperature to which they will be subjected.

Greenhouse and Conservatory.—In cold, frosty weather much care must be exercised to keep the occupants of these places in good health, particularly if they include, as is usually the case, a varied collection of plants. Cape Heaths do not thrive under much artificial heat, while some of the soft-wooded plants, such as Pelargoniums, ought not to be in a lower temperature than 45° Fahr. Where these plants have to occupy the same houses as those derived from Australia they should be placed at the warmest end of the building, in such positions that they may be placed near the glass. Watering must be done cautiously, especially if the thermometer should show a lower degree than that mentioned. Heaths, and other hard-wooded plants of similar habit, should have all the air possible when the weather is propitious, for a close atmosphere conduces to the formation of mildew.

The conservatory must be kept free from all dead or decaying foliage or flowers, and no more water should be used than is necessary to keep the plants in a state of health, for the less moisture there is in the house the better and fresher will the flowers keep. Superfluous moisture may be expelled by keeping up a sufficient heat. It is always best to ventilate in the early part of the day, closing the lights early, so as to aid in maintaining the temperature during the night.

PITS AND FRAMES.

Under this heading must be included both hot and cold pits, wooden frames, and boxes for placing in hot-beds. The former are most useful for protecting plants which are required for

the flower-garden during summer. The gentle heat generated by the hot-water pipes will be sufficient to keep the frost away from such plants as Pelargoniums, Ageratums, Lobelias, and other half-hardy kinds required for the aforesaid purpose. They are also well adapted for propagating most of such plants. Unheated pits are serviceable for growing Violets, and for wintering many plants which are too sensitive to cold to withstand the rigour of an English winter, as, for example, Cinerarias, Calceolarias, Stocks, and similar plants. Frames are also exceedingly useful, as they may be moved from place to place and put over beds of various plants, either to bring them forward, or as a protection from cold. They are also much in demand during spring for "hardening off" numerous plants before their exposure to the open air. Cuttings of Chrysanthemums may be inserted in them, and if there be no room in the heated pits, pots of Sweet Peas may be forwarded in them for planting out later on.

FLOWER-GARDEN AND PLEASURE GROUND.

If the weather be frosty wheel manure on to all vacant ground, to be dug in as soon as conditions are favourable. Clear up any weeds and other rubbish which may have accumulated during boisterous weather. When atmospheric conditions permit, prune and nail deciduous climbers and other shrubs. Push forward any ground work that can be done before tasks of a more urgent character reveal themselves. Should there be very severe frost it may be necessary to protect some of the more tender plants, such as *Magnolia grandiflora*, Euonymus, Tea Roses, Escallonias, Ceanothus, &c. Nothing is more suited to this end than bracken. Ground around the roots of plants covered with decaying leaves will be hindered from becoming frozen. Occasionally deciduous trees and shrubs may be planted, and many hardy plants may be divided and replanted.

FEBRUARY.

PLANT-HOUSES.

Orchid Houses.—Many *Odontoglossums* of the crispum type will now be showing their flower-spikes, and these should be carefully inspected every day for slugs and snails, which are particularly fond of them. If the past month has been severe, rendering much fire-heat necessary, thrips will most probably have

made their appearance. Should any be visible, dip the plants occasionally in soft-soap and water. *O. citrosmum* will also have commenced growth, and should be repotted where necessary, before the roots are far advanced. Some of the winter-flowering section of Cattleyas and Lælias will also be starting, and will therefore need attention. Any which require repotting or surfacing should be attended to. *C. labiata* and *C. Dowiana* will be the first to require care. Good fibrous peat and clean crocks only should be used. Any Dendrobiums which have finished their flowering period and are starting afresh should also be potted or put into fresh baskets as need arises. *Vanda Amesiana*, *V. cærulea*, and various other orchids which require repotting, should be attended to on the first available opportunity.

Towards the end of the month, when the days lengthen and the sun has more power, it may be found advisable and necessary to put up the blinds, for many plants suffer more from sudden bursts of sunshine than if they were exposed to it continually. Blinds will also prevent the necessity of damping down too frequently, which, at this season of the year, owing to extremely low outside temperature at night, is apt to cause drip through the condensation of the moisture on the roof-glass.

Hothouse.—Numerous plants in these structures will be starting into growth, therefore potting will be general. If the necessary materials were prepared last month, as then advised, the work may be taken in hand at the expiration of the first fortnight. All pots and drainage appliances should be perfectly clean. Most stove-plants succeed in a mixture of loam, leaf-mould, peat, and sand. There are, however, a few which need a special soil, as, for example, *Ixoras*, *Dipladenias*, *Phryniums*, &c., which thrive best in sandy peat. Particular care is needed in potting. Such plants as have thick fleshy roots should not have the soil made too firm, while those of a more fibrous nature take hold much better if it be pressed down hard.

Gloxinias, Caladiums, and other bulbs, which have been lying dormant through the winter, should now be induced to commence growth. The former succeed best in sandy peat to which a little loam has been added. The latter require a rich, light, rough soil, so that their roots may ramify freely. The temperature should be increased to 65° at night in mild weather, and from 70° to 75° in the daytime.

Intermediate House.—Gardenias, and other plants of a similar nature that require a

temperature of from 55° to 60° and are now coming into flower, should be exposed to the light as much as possible. Weak manure-water should be given to those whose roots fill the pots, to assist them in swelling their buds. Many of the Java section of Rhododendrons should be potted before growth and root-action have made much progress. Most of the palms find the temperature of the intermediate house congenial, and those should be potted which require it. They all succeed well in a compost of light rich loam, peat, and leaf-soil. They should be potted rather firmly, as many of them make a quantity of fibrous roots. Begonias of the tuberous-rooted kinds should be started into a renewal of growth.

Forcing House.—Continue to introduce plants, to bring forward as recommended for last month. In addition to these, cuttings of various other plants may be rooted in this structure. Among these may be included Perpetual Carnations for winter flowering, Heliotropes, Bouvardias, Harrison's Musk, and various stove-plants. Many kinds of plants may now be raised from seed.

Greenhouses and Conservatory.—This month is usually one of the most pleasant of the whole year in this department, as there are so many spring flowers that have been brought forward in heat, which will now be in bloom. Much care, however, will be needed to keep the flowers fresh, as probably the weather may be very changeable.

Cinerarias, Cyclamens, Primulas, and other flowers of their class should now be had in abundance; while the numerous bulbs that have been brought forward all tend to make the conservatory gay. Any climbers that need pruning should receive attention without delay, as the sap will soon be active.

The propagation of various soft-wooded plants for summer flowering should be taken in hand. These include such as Petunias, Heliotropes, Pelargoniums, and Fuchsias. Fancy Pelargoniums intended for early flowering should be removed to their final quarters. Many hard-wooded plants, particularly those that bloomed in the autumn or early winter, will now be starting into growth, and these should be repotted. Such climbers as Lapagerias, Tecomas, Rhynchospermums, &c., that need top-dressing or their border extending, should be looked to. Heaths and many New Holland plants will be revealing their flower-buds. If these require retarding for any special purpose, this should be done before the buds get too far advanced. For this

purpose they should be kept in the coolest end of the house, and air admitted on all favourable occasions.

PITS AND FRAMES.

With warmer weather and an increase in the latent store of heat, many plants will be starting into new life. Where Polyanthus, Auriculas, Stocks, Border Carnations, Aquilegias, Hydrangeas, Marguerites, and such-like plants have been wintered in these contrivances, they should be looked over, and all dead leaves removed. Air should be ungrudgingly admitted on all propitious occasions. The sun being bright and the weather mild, the lights may be removed altogether for an hour or two in the middle of the day. Make another sowing of Sweet-peas and other half-hardy annuals, such as Sweet Sultan, Gaillardias, and Perpetual Stocks for cutting. Violets will need plenty of ventilation when the weather is fine. They must, however, be well covered at night to protect them in case of frost.

FLOWER-GARDEN AND PLEASURE-GROUND.

When the weather permits, push forward with all digging and the planting of deciduous shrubs, as such work should be brought to a conclusion by the end of the month. Where any new turf has to be laid, it should be done without delay; walks should be regravelled if necessary. Sweep and roll lawns to give them a tidy appearance. Look over the flower-beds, and if any of the spring bedding plants, such as Daisies, Polyanthus, Myosotis, Silene, &c., have been lifted by frost, press their roots in again. All dead leaves should be removed. Look well after mice where Crocuses are growing, as they are often very troublesome just as the flower-buds are appearing. Should any pruning remain undone, finish it as soon as possible, as the sap will very shortly commence to flow.

MARCH.

PLANT-HOUSES.

Orchid Houses.—Of all the trying periods of the year March is one of the worst with which a gardener has to contend. Often there are cold winds blowing from the north-east, which lower the temperature of the houses, so necessitating the consumption of a large quantity of fuel in order to maintain the requisite degree of warmth. While these remain, frequent damp-

ing down must be done, or otherwise the young growths will soon be covered with yellow fly and thrips.

Oncidiums of the autumn and winter flowering section, such as *O. Lanceanum*, *O. ampliatum*, *O. majus*, and *O. pulvinatum*, will now require potting. After this is done, they should be placed in a temperature of 60° at night, and from 70° to 75° during the daytime. Such varieties as *O. incurvum*, *O. ornithorhynchum*, *O. tigrinum*, *O. Marshallianum*, *O. crispum*, and *O. sarcodes*, should be grown with the Odontoglossums. Some of the Cattleyas, notably *C. Aclandiae*, *C. superba*, and *C. Schilleriana*, will now need potting. Use clean pots and crocks, for these plants dislike sour soil. The remarks applied to Lælias last month, hold good during the present one. All that have commenced new growth should either be top-dressed or placed in new baskets if they require it. Dendrobiums will be gay during March. Those which have finished blooming should be attended to, and any that need potting should have this taken in hand before growth has advanced too far, as the process retards it. Many of the plants in the intermediate house will now need removal to fresh pots. Maxillarias, Lycastes, and Cypripediums that are starting into growth will also require more root-room. Calanthes that have been at rest will be resuming active life again. When the new growths are about an inch long, they should be potted. The compost used should consist of rich turfy loam and dried cow-dung. The base of the old bulb should be just covered with the soil, and a small stick used to support each till it has become firmly established in its new quarters. No water will be needed for some time except for damping over the surface with the syringe. They should have a temperature of 65° at night, and of 75° to 80° by day. Repot Odontoglossums that are just renewing their growth. Be careful to keep these plants shaded from the sun, and use plenty of water, both at the roots, over the stages, and amongst the pots.

Keep a little air on, from both top and bottom ventilators, whenever the weather will permit the practice. The temperature at night should be from 45° to 50°, and by day from 50° to 60°, according to the weather.

Hothouse.—The present is a busy month in this department, as many plants will need repotting, cuttings must be put in, and seeds sown. Such plants as Crotons, Dracænas, Allamandas, Alocasias, Marantas, and stove-plants in general will need fresh pots. Since so many

plants are required for general house decoration, they must be provided of various sizes. To attain this end a variety of cuttings should be rooted. Among these we may mention *Andropogon schoenanthus*. Aralias of numerous kinds should be grafted, Ardisias raised from seed, Curculigo by division, *Cissus discolor* from cuttings, Eranthemums by cuttings, Cyperus by taking off the heads with two inches of stem, and inserting them up to the pennates in a mixture of peat and sand, Epiphyllums by grafting, *Goldfussia anisophylla*, Pandanus, Panicum, Pellionia, Phrynium, Pilea, Reidia, &c., from cuttings; and Rivinas, Torenias, Smilax, and the various forms of Asparagus from cuttings. These must all have attention, in order that a regular supply of such plants may be had as required. Pot up Caladium bulbs and increase their number by dividing them into as many pieces as there are eyes.

Intermediate House.—Divide and pot all such plants as Aspidistras, Clivias, Farfugiums, Hedychiums, *Myrsiphyllum asparagoides*, Phormiums, Ophiopogons, *Rhapis flabelliformis*, and *Curculigo recurvata*. If this be done this month, nice well-established plants may be had for use in the autumn. Sow seed of *Aralia Sieboldii*, Grevillea, and other plants, and propagate by means of cuttings Libonias, Eupatoriums, Begonias, Linums, and similar plants for winter flowering. Many of the Ferns will also require repotting, and any seedlings should be pricked out into pans as they get large enough to handle.

Forcing House.—Continue to introduce plants required to be brought into bloom, but as the days get longer they will come into flower with far less artificial warmth than in the previous months. It will therefore be no longer necessary to place so many in heat at one time. Cuttings of such plants as Aloysia and Coronilla should now be rooted. The former will be found very serviceable, if planted out, for cutting in the autumn.

Greenhouse and Conservatory.—Hardwooded plants will require constant attention during this month. The bright gleams of sunshine and the parching winds have each to be contended with. The former causes the temperature to rise suddenly, while the latter prevents the admission of air to regulate it. Azaleas that have been forced, and have finished blooming, should have the old flowers picked off, and if the plants require repotting, this should be done before growth has too far advanced. If there is no lime in the soil, some good turfy loam may be mixed with the peat, but where lime is

present, this should be discarded, nothing being used but sharp sand to mix with the peat.

Camellias whose flowering period is over should be repotted. We do not advocate placing them in heat to forward their growth, except for the purpose of causing them to flower earlier, as more robust shoots are developed in a cooler atmosphere.

The conservatory will now have a gay appearance, with the various kinds of flowers that have been forced; and as a number of these will be tender, the house should be shaded to protect them from the direct rays of the bright sunshine. More water should also be used to keep the house cool. Sudden changes in temperature must be avoided by keeping the ventilators in use when possible.

PITS AND FRAMES.

These will now be filled to their utmost capacity, as many plants which have been occupying the houses will be transferred to them towards the end of the month. They will also be useful in retarding Tulips, Hyacinths, Freesias, and such-like, and for the protection of the early-flowering Gladiolus. Florists' flowers, too, will still need their shelter. Violet cuttings may be rooted in them.

FLOWER-GARDEN AND PLEASURE GROUND.

Any leaves which have been blown about by the wind should be cleared away. Edge grasswalks, sweep and roll lawns, and make all tidy. When the weather is favourable finish digging shrubbery borders, and prune any evergreens that may require it. In warm localities many half-hardy plants that have occupied cold frames during the winter may be planted out towards the end of the month, as may also Carnations, Pentstemons, and various other plants. Rearrange herbaceous borders, and divide plants where necessary.

Helianthus, Chrysanthemums, Heleniums, Pyrethrums, and other autumn-flowering plants, should have due attention paid to their requirements.

Spring bedding plants will soon be gay, especially those planted early in the autumn. Many of the Violas, Silenes, Polyanthuses, Myosotis, Arabis, and others that bloom early, will be in flower.

Keep the beds under inspection and remove all decayed leaves. In dry weather stir the surface of the soil with a hoe, to destroy any little weeds which may be making their appearance. Put sticks to Tulips and Hyacinths, to

prevent them being broken off by high winds, and pay particular attention to catching mice, which are often very obnoxious, and do much harm to Crocuses and Snowdrops. Towards the latter end of the month plant out Sweet-peas and other annuals which have been raised in pots. Protect them with evergreen boughs if the weather should make it necessary.

APRIL.

PLANT-HOUSES.

Orchid Houses.—This is a busy month with all gardeners, as so many plants require attending to. In this department there is much necessary work, caused by the rapid growth and development of plants under the fostering influence of increased sunshine and longer days. *Cœlogynes* will have finished their flowering period, and therefore will either need potting or fresh surfacing. Those of the *cristata* type do best in baskets suspended from the roof. Many of the *Cypripediums* and *Dendrobiums* will also need repotting as they start into fresh growth; as will likewise *Epidendrums*, *Masdevallias*, *Phaius*, *Sobralias*, &c. The two last-named require rather large pots, and should be grown in a mixture of turfy loam, peat, leaf-soil, and sand. The pots should be well drained, as, during the growing season, these plants consume abundant supplies of water. The former does well in the hothouse or any place where it can have bottom heat. Shade, however, is necessary, or the leaves may scald. *Vanda teres* will now be showing flower and should be shaded from the sun. Any of the other species that need potting should be looked to, as, if left to themselves, they are apt to become leggy. Attend to *Cattleyas*, and repot or surface any which are commencing growth. As the weather becomes milder there should be a free circulation of air, but cold draughts must be carefully avoided. The *Odontoglossum* house will not need fire-heat, unless an occasional frosty night should make an exception. Keep the stages, paths, and pots well moistened by damping down two or three times daily. The plants may also be syringed both morning and evening. If the sphagnum is growing well, it may be taken as a sign that the plants are receiving the right treatment. The *Dendrobium* house requires to be kept at a temperature of 70° at night during mild weather, but may be allowed to fall 5° or 10° if the season is cold, as too

much fire-heat is harmful, and encourages insect pests. The plants in active growth may be watered from above with a rose. Shade from the direct rays of the sun, but raise the blinds as soon as the sun is off them, in order that its rays may keep up the temperature of the house.

Hothouse.—The greater part of the potting in this department will have been finished, except in the case of young plants that have been propagated from cuttings or seed. Do not on any account allow these to become either pot-bound or overcrowded in the seed-pans, for if either of these contingencies arise, the plants will become stunted in their growth or spindly while young.

All seedlings should be kept as near the glass as possible, and those newly placed in small pots should be kept close and shaded from the sun.

Pot up *Achimenes*, *Gesneras*, and *Gloxinias*, and start them into growth. Continue to propagate such plants as *Euphorbia jacquiniæflora*, *Ixoras*, *Begonias*, *Æschynanthus*, *Acalyphas*, *Dracænas*, *Coccocypselum discolor*, *Pandanus*, *Gardenias*, and *Thyrsacanthus rutilans*, as many of them will be useful either in producing a supply of flowers or furnishing plants for house decoration. Shade will be needed whenever the sun is bright, and this will prevent the necessity of too much watering. Keep the syringe well at work amongst the foliage, in order to destroy all insect pests. The temperature should vary from 65° at night to 85° by day under sun-heat.

Intermediate House.—*Rhododendrons* of the *Javanicum* type will now need special care. They must be potted firmly in peat, and afterwards carefully watered. *Streptocarpus* will now be in bloom, and if seed is needed, the flowers must be kept dry. Pot on seedlings as they get large enough. Many palms will also need looking after, as thrips are nearly certain to make an appearance. Air should be admitted liberally on all favourable occasions. The temperature should range from 55° at night to 65° or 70° by day.

Forcing House.—Sow seeds of *Ricinus*, *Tobacco*, *Solanums*, and other plants of ornamental foliage, to produce, early in the month, plants for use in sub-tropical gardens later on in the year. If these are grown on in a brisk heat till the middle of next month, and then gradually hardened, they will become large plants by the time it will be advisable to plant them out. It will not be necessary to introduce any more hardy shrubs to be forced into flower-

ing, as so many other things will now be coming into bloom naturally. Many cuttings, nevertheless, will need to be put in for the purpose of furnishing the flower-garden during summer, and no better place can be found for them than the forcing house.

Greenhouse and Conservatory.—The latter will now be gay with the various plants that have been pushed forward into early flower, and a great number of hard-wooded New Holland plants which have their natural period of efflorescence at this time of the year. There are several *Acacias*, *Chorizemas*, *Clematis*, *Aphelaxis*, *Pimeleas*, *Leschenaultias*, *Hydrangeas*, *Roses*, &c. These, together with bulbous and herbaceous plants, will make a fine display. Care must be taken, however, not to overcrowd, as is much too often the tendency when there is such a tempting array of flowering plants. Propagate such things as *Francoas*, *Pleromas*, and *Rochea falcata*. Sow *Mignonette*, *Rhodanthe Manglesii*, and other hardy and half-hardy annuals, to give a supply of cut flowers and decorative plants. Tuberous *Begonias* should also be potted for flowering later on. The pretty little *Crassula jasminoides* and other species should be rooted, so that good plants may be had for another season. Fancy *Pelargoniums* will be in active growth, and as the pots get filled with roots, they should be supplied with weak manure-water, to assist them in sending up strong trusses of flowers. *Fuchsias* that were started last month will now need repotting. Cuttings may also be rooted, to give good plants for autumn flowering.

PITS AND FRAMES.

Propagate *Dahlias*, *Cannas*, *Zonal* and other *Pelargoniums*, for flowering in winter, *Heliotropes*, and other bedding plants. Pot off *Carnations* that were rooted in heat last month. Harden bedding *Pelargoniums* and other plants of a like nature. Sow seeds of *Asters*, *Stocks*, *Balsams*, *Chinese Primulas*, ornamental grasses, &c. Plant out herbaceous *Calceolarias*, *Pansies*, *Hollyhocks*, *Pentstemons*, *Gladiolus*, &c., towards the middle of the month, or, in warm sheltered situations, at the beginning of it. By so doing more room in the frames will be available for less hardy subjects.

FLOWER-GARDEN AND PLEASURE GROUND.

Evergreen shrubs, such as *Hollies*, *Rhododendrons*, *Kalmias*, and *Andromedas*, should be planted in showery weather. Tidy up all herbaceous borders, and do everything in the

way of transplanting, &c., not already done without delay. Grass will now be growing well on the lawns, and will need cutting. It should be swept first, then rolled, after which the machine may be run over it. Edge and clear up gravel walks, and give immediate attention to any re-gravelling which may be necessary. Look over and prune *Roses* at the beginning of the month, and replace with others all which have succumbed to the winter frosts. Spring bedding should be looking very bright at this season, as most of the plants will be in flower. Keep the edges of the beds trimmed, and clear off all decayed leaves or other rubbish that may have been blown on by the winds.

M A Y.

PLANT-HOUSES.

Orchid Houses.—Many plants will now have reached their full development with regard to size, and when such have got firmly established in the new material in which they were potted plenty of water should be afforded them. *Sobralias* should be potted before growth is far advanced. These plants succeed best in a light, rich compost, in which their thick, fleshy roots can more easily push their way and ramble at will in search of nutriment. *Odontoglossum Inseayi*, *O. I. leopardinum*, and other varieties of this section should also be potted and grown in the Mexican or intermediate house. Other occupants of this structure will also need attention. *Zygopetalums*, which should have a place in all gardens on account of the fragrance of their flowers, should now be potted. They thrive most conspicuously in a mixture of good fibrous loam, cow-dung, crocks, and a little peat. They must be very carefully drained, as they are moisture-loving plants. *Phalænopsis* that require fresh pots, baskets, pans, or blocks, should be accommodated therewith. This lovely tribe is not so difficult of management as some people suppose if they receive proper attention. They should be kept shaded from the sun, have a uniform temperature, with a humid atmosphere. Many *Cattleyas* will be in flower during this month, and these, if possible, should have a rather more airy atmosphere than the others to prevent their flowers from spotting. When flowering is over look to their roots, and if any require potting this should be done. More moisture should afterwards be allowed them. *Odontoglossums* of the *crispum* type will be

expanding their flowers. Shade for these will be a very essential requirement, and plenty of water must be kept about the paths and stages. The top and bottom ventilators should also be opened when the weather is warm so that the house may be kept as cool as possible. *Dendrobiums* of the *densiflorum* type, that is, all those with persistent foliage, will be going out of flower. As soon as the flowers are faded the plants should be potted in order that their roots may be as little injured as possible. After this operation they should be subjected to a temperature of 70° by night and from 80° to 90° by day, according to the weather. Syringe the plants over the foliage twice daily during warm weather, and shade should be afforded at all times when the sun is bright.

Hothouse.—Most of the plants that were potted in March will by this time have got well rooted, so that liquid manure may be given where it is intended to keep them growing. Plants of *Allamandas*, *Stephanotis*, *Dipladenias*, &c., will produce more flowers if liberally treated thus. Many of the fine-foliaged plants and palms will also be benefited by applications of some description of stimulant. With increased heat various insects will become troublesome. It will therefore be necessary to prevent their ravages. Syringe or dip the plants frequently with some insecticide. Start plants of *Poinsettia*, and when the young shoots are forward enough they should be taken off and rooted in close, moist heat. *Euphorbia jacquiniæflora* may also be propagated now. The temperature at night should be about 70° Fahr., with an increase of 10° to 20° by day under sun-heat. Shade in bright weather, but draw up the blinds early, and close the house so as to maintain a good night temperature without the assistance of much fire-heat.

Intermediate House.—Pot on *Bouvardias* as they require it, and towards the end of the month, when they are well rooted, remove them to a cooler structure where they may get more air. *Gardenias* will be flowering freely, and when new growth is made cuttings should be taken off and rooted to give young plants.

Many Ferns will now be resuming active growth. Shade should be afforded these, or the young fronds may get scalded. Pot up any which require it, and keep remainder well watered.

Forcing House.—It will not be found necessary this month to push forward any hardy shrubs for decorating the conservatory, as plenty of flowers will be in bloom under the natural

influence of the sunshine. There is, however, a number of useful plants that may be caused to flower which would not otherwise do so till a much later period of the year if not forced. Take, for example, *Tuberoses*, *Lilium Harrisii*, and some other choice flowers. It will therefore be necessary, if a quantity of flowers are required for cutting, to bring them forward artificially.

Greenhouse and Conservatory.—Hardwooded plants of various kinds will now be in bloom, and when their flowers are over the plants should be cut back to induce them to make a clean growth for another season. The potting of plants of this kind should be attended to, especially *Azaleas*, *Pimeleas*, *Cassias*, *Heaths*, &c. The soil must be pressed down firmly, as otherwise the roots will not take hold of it. The plants must be well syringed to keep down insects. The conservatory should be kept shaded, and air admitted night and day, in order that the flowers may last as long as possible. Any plants, as, for example, *Pelargoniums*, that are subject to the attacks of aphides, should be cleansed thoroughly before their introduction to the conservatory, as at this time of the year these pests increase very rapidly.

PITS AND FRAMES.

Violets that were rooted in these should be planted out in the open ground early in the month, and their places reoccupied with bedding plants. Perpetual Carnations, which were rooted early in the season, will now require to be potted, and various plants from the greenhouse may be placed in the pits, &c., as space becomes vacant. *Begonias* of the tuberous-rooted section will need potting, and no more suitable place can be found for them than in these structures. Towards the end of the month *Chrysanthemums* will require to be put into their flowering-pots and removed to the open. See that these pots are properly drained, for without this precaution they may become waterlogged. Various kinds of herbaceous plants which were propagated from cuttings put in during the autumn should now be transferred to the open. This will give space for other occupants of a more tender nature, such as *Balsams*, *Celosias*, *Solanums*, *Ricinus*, &c.

FLOWER-GARDEN AND PLEASURE GROUND.

The present is a busy time with gardeners as many summer-flowering plants may now be placed in their permanent quarters. In warm and sheltered situations *Calceolarias*, *Verbenas*,

Stocks, Asters, and similar plants may be put out in the early part of the month. These may be followed by Pelargoniums, Petunias, Fuchsias, and Begonias. Annuals may also be sown to procure a succession to those sown early last month. Sow also Perpetual Stocks for autumn flowering. Stake and tie any plants which require it, taking care not to leave the ties too tight. Grass usually grows very fast during this month, but it should be kept well under at any cost. Walks and beds should be edged, and nothing omitted which tends to give them a tidy and neat appearance. Should the weather prove dry it will be necessary to water all newly-planted shrubs and plants. When this has to be done give a generous soaking, not a mere dribbling over the surface. Keep the hoe at work among seedling plants to check weeds, which at this time of the year grow at a great rate.

JUNE.

PLANT-HOUSES.

Orchid Houses.—The sun will now have great power, therefore it will be necessary to pay much attention to shading. Neglect of this precaution is productive of more harm than any other omission. If plants that have been kept in shade happen to be exposed to sunshine during the hottest part of the day, they are certain to suffer in consequence. *Verb. sap.* Calanthes will now be growing rapidly, and should have an ample provision of water, both at the roots and over the foliage. Dendrobiums also will be in active growth, and will therefore need plenty of moisture. A number of the “cool” Oncidiums will require potting or top-dressing during the month, to give them fresh vigour. Brassias will generally be out of flower, and they should likewise be attended to, as regards potting, &c., before new roots are formed.

As Cypripediums of different varieties are mostly now out of bloom, they should be potted as growth commences.

A great number of Cattleyas will have finished flowering; there are, however, some which bloom during the present month. As they go out of flower and start to make roots, the supply of moisture should be increased. It is a mistake to allow the flowers to remain on the plants too long, as they have a tendency to exhaust them. One of the chief points in the successful cultivation of these plants is the keeping them in a uniform temperature, with plenty of light, but

shaded from the direct rays of the sun. Air should be freely admitted, but cold draughts must be avoided. Look well after all kinds of insects and other vermin, such as snails, for they are very troublesome.

Hothouse.—Pay close and unremitting attention to the inmates of this department, for insects of all kinds thrive wonderfully under the genial heat there afforded. Sponge, syringe, or dip any that show signs of these obnoxious creatures.

Many of the summer-flowering plants will now be in full bloom, as, for example, Dipladenias, Ixoras, Allamandas, Clerodendrons, &c., and all such should receive every necessary care, and not be allowed to deteriorate for want of moisture. Many fine foliage plants will also be making active growth, and these should be liberally treated. Pot up a batch of Caladiums for late use. Bulbs started in this month will make a fine show till late in the season. Pot on young plants as they require it, taking care to allow none to suffer through becoming pot-bound.

Such plants as Torenias, Acalyphas, Ardisias, Winter-flowering Begonias, Epiphyllums, Eranthemums, *Euphorbia jacquiniæflora*, Goldfussia, Justicia, and other winter-flowering kinds should be placed in heated pits, where they may have the benefit of sunshine to ripen their wood.

Palms of all kinds will now be making active growth, and should have plenty of water, as otherwise their fronds will be imperfect. Attend to the potting of ferns before they become pot-bound, or it will be difficult to get the water through the old ball afterwards.

Intermediate House.—The first batch of Bouvardias should now be put into their flowering-pots, using for the purpose a light rich compost. Do not pinch them subsequently, but allow all shoots to grow up strong. Heliotropes for winter-flowering should now be potted up. These plants should on no account be allowed to get pot-bound, or they will not make satisfactory progress. Tuberoses should be potted, and if, after they have started, they are taken and plunged in a cold frame, they will give a supply of flowers through the autumn and winter months.

Pot on seedlings of Celosias, Cockscombs, Streptocarpus, &c., as they become large enough to handle, and shade for a time till they have got well established, then expose to the sun. Gloxinias, Achimenes, and Gesneras should be potted as they require it.

Greenhouse and Conservatory.—Many

climbers in these structures will now be making active growth, and as the young shoots of some are very susceptible to the attacks of slugs, a search should be made for these, late each night and early in the morning.

Lapagerias, Passifloras, Habrothamnus, Chorizemas, Kennedys, Jasminums, *Solanum jasminoides*, *Clematis indivisa*, and some others will need a quantity of water to keep them growing. Cyclamen should be potted on into larger pots before they become pot-bound, as should also the early batch of Primulas and Cinerarias. Hard-wooded plants will, towards the end of the month, have completed their growth, and many of them may then be placed out-of-doors in a sheltered place on a bed of ashes. Pelargoniums, both show and French varieties, will now be in full bloom, and should therefore receive every attention in the way of watering. If the soil be allowed to get dry the flowers will not open properly, neither will they last so long. Plenty of air should be allowed them by night and day, unless the weather is cold.

PITS AND FRAMES.

Zonal Pelargoniums for winter flowering should be potted on as soon as the roots reach the sides of the pots. Plant out Richardias, *Solanum capsicastrum*, and other things, to be lifted in autumn for flowering in winter. Pot on Perpetual Carnations, Fuchsias, Sweet-scented Geraniums, *Aloysia citriodora*, Celsias, Begonias, &c., intended for autumn and winter decorations. Do not permit any to suffer through want of water. Chrysanthemums that have not yet been placed in their flowering-pots ought to be so treated without delay. Propagate Petunias, Marguerites, and such plants, for late use. Sow Mignonette in pots for the conservatory. Stake and tie all such plants as require it.

FLOWER-GARDEN AND PLEASURE GROUND.

Sow seeds of biennials and perennials thinly, in order that the plants may not become overcrowded. The following is a good selection:—Anemones, Wallflowers, Sweet Rockets, Polyanthus, Foxgloves, Canterbury Bells, Lunaria, Chelone, &c.

Thin out annuals as they become large enough, and finish planting bedding plants. Every operation should be performed at its proper time. When flower-beds have to be cleared of winter and spring bedding-plants, this should be done as each variety goes out of flower, and they should be replaced by those that are to occupy the beds during the summer. Sub-tropical

plants may be put out now, as the weather will be sufficiently warm for all kinds of half-hardy plants. Water liberally in the event of hot and dry weather. Herbaceous borders will need much care, as a number of plants will require staking, and others cut down, as they cease flowering, to make room for those which tend to spread.

The rose-garden will now be gay, but when the flowering season is past the beds look untidy, unless something be planted amongst them. Gladiolus started in pots may be turned out here, as they make a grand display during the autumn season. Any shrubs which have been used for forcing may be turned out. Cut down *Deutzia gracilis* to cause it to make new growth. Dahlias and other tender plants ought not to be planted out till all danger of frost is at an end, for if once cut down they will not grow satisfactorily afterwards. Keep the grass cut short, and see that neatness prevails everywhere.

JULY.

PLANT-HOUSES.

Orchid Houses.—Many Cattleyas will still be in bloom, among them being *C. Gaskelliana*, *C. Warneri*, *C. gigas*. While they are flowering it will be necessary to keep them well supplied with water, for at this warm season of the year the flowers would soon fade if they were allowed to get dry. When flowering is over, less water will be needed. At the same time they must not be allowed to dry up in the heated atmosphere. Air should be freely admitted at all times during this month, but cold draughts at night must be avoided. *Lælia purpurata* and some others of that class will need looking over, and if any require potting, this should be done. Dendrobiums in full growth must be freely supplied with water, both at the roots and overhead. They should also be kept in a high temperature. Close the house early so that the thermometer may indicate 90° to 100° F. with the sunshine. Odontoglossums should be kept as cool as possible by a free circulation of air. Plenty of moisture on roots, paths, and stages alike must be given, with shade constantly when the sun is bright. When available use rain-water for syringing, as this does not discolour the leaves. Calanthes, Phaius, and others with large leaves will need plenty of water with a high temperature to promote as free growth as possible, for unless this is made

during bright sunny weather, it is often necessary to use increased fire-heat in autumn to mature the growth. If insects of any kind make their unwelcome appearance, they should be promptly dealt with by either dipping the plants in soft-soap solution or by sponging, taking care not to injure the tender foliage.

Hothouse.—As the heat increases, considerable attention will be requisite to keep insect pests in check, as they increase and multiply exceedingly fast. Mealy-bug is one of the most obnoxious of these that the gardener has to contend with, but every effort should be made to eradicate it. Thin out and regulate shoots of *Clerodendron Balfourianum*, *Stephanotis*, and other stove climbers that they may not become overcrowded. Where plants for table decoration have to be grown to a considerable extent, a suitable selection of these should be made and put forward for the purpose. By potting them now they will become well established by autumn, so that there will be less risk on removing them to a lower temperature. Plants for this purpose should be allowed plenty of room, that they may be thoroughly developed. *Cocos Weddelliana*, *Cyperus alternifolia variegata*, *Aralia Veitchii*, *A. V. gracillima*, *Asparagus plumosus nana*, Crotons of sorts, *Dracæna gracilis*, *D. rubra*, and others of like character, *Eulalia japonica*, *Caladium argyrites*, *Pandanus Veitchii*, *P. javanicus*, small plants of *Ardisia*, and other berry-bearing species. Seed of the Common Asparagus may also be sown in pots to supply greenery during the winter months.

Intermediate House.—Celosias, Cockscombs, Torenias, and various other free-flowering plants of similar nature that are grown for the object of furnishing the conservatory, should be potted on as they require it, and fresh seed should be sown to provide plants to take the place of those which have finished flowering. Gloxinia plants in flower should be kept well shaded from the sun, and any varieties that it is thought desirable to increase should have some of the best leaves removed for this purpose. If these leaves have the main ribs cut through with a sharp knife, and are then pegged on the surface of pans filled with a mixture of finely-sifted peat and sand, afterwards being plunged into a moderate hot-bed, they will soon form corms. These, by the end of the season, will have grown large enough to make strong plants the following year.

Achimenes and Gesneras should be staked as growth proceeds to prevent them bending down.

Greenhouse and Conservatory.—Most of the hard-wooded plants will by this time have completed their growth, and may be stood in shaded situations out of doors, where they will thrive far better during the next three months than under the heat of a glass structure. Their places may be occupied by some of the more tender flowering plants, or for growing on Fuchsias, Balsams, *Campanula pyramidalis*, tuberous-rooted Begonias, and similar things for decorating the conservatory, as it will be necessary to make frequent changes in the latter structure at this time of the year, if it is to be kept tidy, for, owing to the heat, flowers soon fade, and on that account necessitate constant removals.

PITS AND FRAMES.

This is a good time to layer Perpetual Carnations for winter flowering. If the pots can be plunged to their rims in an old hot-bed, and plenty of room allowed between them, so that the shoots can be brought down and pegged into the soil, they will soon take root. When layered they should be well watered, and afterwards covered with the lights and shaded from the sun. Plants rooted from cuttings in early spring will need potting on, and either standing on a bed of ashes in the open, or in a cold frame, where they can be protected in case of heavy rain.

Mignonette for winter flowering should now be sown. If the weather be hot and dry, shade till the seedlings appear above the soil. Zonal Pelargoniums for winter flowering should also be put into their permanent pots, and afterwards stood on a bed of ashes in the full sunlight. Heliotropes, Bouvardias, Primulas, and Cinerarias will need attention, as the plants become sufficiently large to be shifted, for if they are permitted to get pot-bound, they seldom make much further progress. Cuttings of *Hydrangea hortensis*, Otaksa, and Thomas Hogg, should be inserted in cold frames to supply plants which will flower early in spring. Pot on Eupatorium, *Linum trigynum*, and other plants of similar habit for winter blooming. Sow seed of Cyclamen and Calceolaria where early plants are required.

FLOWER-GARDEN AND PLEASURE GROUND.

Make another sowing of Sweet-peas at the commencement of the month to give a late supply of bloom, also sow seed of Brompton, East Lothian, and other Stocks, various herbaceous plants, such as Aquilegias, Delphiniums,

Polyanthus, Antirrhinums, Violas, *Campanula pyramidalis*, &c. Cuttings of double Wall-flowers, Pinks, &c., should also be inserted now. Lift Anemones, Narcissus, and other roots and bulbs as their foliage dies down. Many plants in this department will now be revealing their flower-spikes, and will therefore need staking and tying to prevent them being blown about. Commence budding Roses towards the close of the month. It is not advisable to begin too soon, however, in forward districts, as the buds often start into growth, and on that account are sometimes killed if severe weather follows. Cuttings of the half-ripened wood will root freely at this time of the year if inserted under hand-lights, or in cold frames behind a north wall, where there is but little sun. Flower-beds will now require constant attention, for if the weather is dry, frequent and copious waterings will be necessary. Peg down and pinch any plants growing out of character; remove all dead flower-stalks to preserve a tidy appearance. Some of the stronger-growing plants, as Hollyhocks, Dahlias, Helianthus, &c., would be greatly benefited by being watered with liquid manure. Most of the sub-tropical plants will be making rapid progress, and will therefore require looking to. Run the hoe through the beds and amongst the plants to keep down weeds. Mow lawns and edge walks; trim and tie creepers as growth proceeds, in order to prevent them being broken off by high winds.

AUGUST.

PLANT-HOUSES.

Orchid Houses.—A number of the plants in these houses will now be in active growth, and for this reason must be kept warm. Among these may be mentioned those of the *Phalænopsis* family, which require a warm, even temperature. Dendrobiums will still demand plenty of heat and moisture. The house may be damped down with manure-water, using the same for the evaporating troughs. Keep a sharp look-out for thrips, which are very destructive to the young foliage. If any of the weevils are found cut away the parts affected at once and burn them, as nothing does more harm to Dendrobies than these minute creatures. Odontoglossums of the crispum section will generally have gone out of flower, and some will be starting to develop new growth. Any that require potting should be attended to before new roots are formed, as

it is a great mistake to injure them by the process of transplanting to larger pots while in active growth. See that all pots and crocks used are quite clean. After potting shade the house a little more in bright weather, and keep the atmosphere closer for a short time, till the roots get active. *Odontoglossum vexillarium*, *O. Phalænopsis*, and some others of the same class, need a warmer temperature; from 60° to 65° at night suiting them admirably during this month. Keep up plenty of humidity in the atmosphere by constant damping down, and keep a sharp watch for red thrips, which finds its way into the young sheaths. *Epidendrum vitellinum majus* and some others will be improved by potting now. They should be grown with the cool Odontoglossums. Lycastes and Maxillarias will have completed their growth, so that they will need less water. The remarks that were given last month still apply to Cattleyas. When the nights are cold less air should be admitted, and a little fire-heat should be applied to cause a circulation of air.

Hothouse.—Poinsettias, *Euphorbia jacquiniæflora*, *Amasonia punicea*, and other winter-blooming plants, should be exposed to the sunlight for the purpose of ripening their shoots. This is a good time for potting Anthuriums in order that they may be well established before their flowering season comes round. Begonias of the section flowering in winter should also be potted on, and kept near the glass, to encourage a sturdy habit. As Caladiums finish their growth give less water, but do not dry them off too rapidly.

Where any palms need to be potted, perform the work during the current month so that they may become well rooted before the winter approaches. Ferns should also receive attention; particularly a batch of Adiantums for winter decorations should be potted into pots of a size larger, and seedlings should be pricked out into pans or pots for spring use. Take cuttings of Coleus and other plants of a tender nature, and root them in gentle heat so that they may grow bushy.

Greenhouse and Conservatory.—When the foliage of hard-wooded plants has grown firm, and before they are taken indoors, is a good time to look over them and rid them of insect pests. They may for this end be laid down on their sides, and washed with the garden engine or syringe, taking care to cleanse the under sides of the leaves. If they have two or three similar dressings they will be freed from insect plagues. Cuttings of show and fancy Pelargoniums that

were put in last month will be ready for potting. When doing this choose a light, rich soil; do not over-pot, and use plenty of drainage material. Afterwards stand the plants in a cold frame or on the greenhouse shelf. Fuchsias may also be rooted now to give a supply of young plants for early display. *Rochea falcata* will now be in flower. When the flowers are over take off all young growths for cuttings, and insert them in a light, sandy soil; then put them on a dry shelf till rooted. Cactuses will have completed their growth, and therefore will need less moisture. These plants thrive with abundance of air and a dry atmosphere. There will still be a sufficiency of plants in flower for decorating the conservatory, as, for example, *Lilium lancifolium*, *Hyacinthus candicans*, Gladioli, Hydrangeas, Balsams, and many other plants of like character raised from seed; as these finish flowering fresh specimens should be introduced to keep up a gay appearance. As the nights get longer there will be more moisture in the atmosphere, therefore it will be necessary to guard against the damping off of flowers. To avoid this ventilate freely on all favourable occasions, and do not water in the evening in damp weather. Much mischief is often done among flowers by keeping the air too humid. A cool, dry, airy place, shaded from the sun, is most suitable for nearly all occupants of the Conservatory while in bloom.

PITS AND FRAMES.

These structures will now be in great demand for the propagation of plants for bedding purposes. If Pelargonium cuttings are put in early there is not so much risk of their damping off in winter as when they are left till next month before the cuttings are taken. The young plants become well rooted, and consequently can absorb more moisture. Frames will also be required towards the end of the month for the protection of the more tender plants and bulbs, such as Freesias, Belladonna Lilies, Nerines, Tuberoses, and Vallota. As all these plants, excepting the first-named, flower in the autumn and winter, it will be requisite to cover them with lights in wet weather. Early Roman Hyacinths, Polyanthus Narcissus, and the earliest kind of Tulips should be potted and covered with ashes. If they can be plunged in a frame it will be so much the better, as they can then be had in bloom very early without forcing. Viola and other cuttings of herbaceous plants should be inserted so that roots may be formed before winter. Attend to previous remarks

about Hydrangeas, Marguerites, Primulas and Cinerarias, Calceolarias, &c.

FLOWER-GARDEN AND PLEASURE GROUND.

Outdoor work during this month is very heavy, so many plants requiring attention. Layer border Carnations at the beginning of the month. Transplant all seedlings of herbaceous plants that were sown last month. Cuttings of Pentstemons, Antirrhinums, and some of the Phloxes may also be taken. About the middle of the month sow annuals for spring bedding, such as *Saponaria calabrica*, *Limnanthes Douglassi*, Virginian Stocks, *Lasthenia californica*, *Nemophila insignis*, *Alyssum saxatile*, *Silene pendula*, Myosotis, &c. Cuttings of choice alpine should now be inserted, as they will then make strong plants by next spring.

Violets for flowering in frames during winter should have liberal waterings with liquid manure to induce them to make plump crowns. Gather lavender and everlasting flowers where they are required for indoor use. Pay attention to staking and tying all herbaceous and other tall-growing plants. Lawns will now need constant attention, for the grass will grow apace; walks must be edged, and the weeds kept down. Flower-beds should have all the dead flowers removed. There is far more pleasure to be derived from a small place well kept than from a large one in a neglected state. Look to drains, and see that they are clear, or heavy thunderstorms may do considerable damage if the water is unable to get away. Shorten the shoots of Laurels, Hollies, and other evergreen shrubs that have grown too large for their position. Hoe and rake borders to keep weeds in abeyance.

SEPTEMBER.

PLANT-HOUSES.

Orchid Houses.—Many of the Dendrobiums will now have reached maturity, therefore they will not need so much water, but will want more air in proportion to ripen their bulbs. If plants of *D. nobile*, *D. crassinode*, *D. Wardianum*, *D. heterocarpum*, and *D. Pierardi* be removed to a cooler house when growth is thoroughly ripened, they will flower much more profusely than if left in the house where others are still in active growth. *D. chrysanthum* will now be in flower. As soon as the flowering period is past, repotting or surface-dressing should be

done, as growth commences immediately afterwards. Towards the end of the month shading may be dispensed with, as the sun has not sufficient power so late in the year to do harm. Some of the early spring-flowering *Cypripediums* should be looked over, and if any need potting this should be done before the days get too short or the temperature cold. If the plants are robust, a mixture of good turfy loam and cow-dung may be used, if the former can be obtained from ground containing a small percentage only of lime. For the more delicate kinds use peat, covering the surface of the pots with living *Sphagnum*. Most of the *Vandas* belonging to the tricolor section may now be potted with safety. These plants are apt to become leggy if left alone too long, therefore their stems should be shortened and the roots brought nearer to the pots. This class only requires something to steady their stems; so that if clean crocks and charcoal are used, covering the surface with a little peat and *Sphagnum*, it will be sufficient. The plants will need but little water at the roots, as the necessary syringing will keep them well supplied with moisture. They should be kept under a temperature of from 65° to 70° at night for the present, with a corresponding rise in the daytime, according to the weather. *Lælia anceps*, *L. albida*, and *L. autumnalis* will now be showing their flower-spikes, and should be kept still in a moist state. Most of the *Cattleyas* will by this time have finished growth, so that watering must be done carefully. *Cælogyne cristata*, *Sobralia macrantha*, *Cymbidium Lowianum*, and some others will still need good supplies of water, and if a little liquid manure could be added to assist them to finish their growth, this would be very beneficial. As all plants mature their growth they should be gradually hardened off, so that they may be the better able to withstand the winter. There are, however, many species still in active growth which will need particular care.

Hothouse.—Many winter-flowering subjects in these structures will now need special attention, in order to induce them to produce their blooms at the time required. *Centropogon Lucianus*, *Eranthemum Andersonii*, *Ruellia macrantha*, *Plumbago coccinea*, *Poinsettias*, and the winter-flowering *Gesneras* should be exposed to the sun as much as possible, so that their shoots may reach their full development. *Caladiums* should be thoroughly dried off, and when all leaves have fallen the pots may be stored away under the stage, but do not remove them into a lower temperature than 60°. *Gloxinias* may

be removed to a house in which the heat does not fall below 50°. If allowed to remain in the warm stove the bulbs will shrivel, or will, if moisture is afforded, recommence growing. *Ixoras*, *Crotons*, *Dracænas*, and other plants should be kept free from insects. *Gardenias* and *Eucharis* for winter-flowering should have liberal treatment, with plenty of heat, the temperature being maintained at 70° by night, with a rise of 10° in the daytime. Towards the end of the month all shading may be abandoned, unless it be in the case of newly-potted seedlings or other plants having but little root.

Greenhouse and Conservatory.—A goodly quantity of *Mignonette* should be sown during this month—one lot at the commencement, and another towards the latter end. *Chrysanthemums* will demand special care, including disbudding and protection from frost. Water must be given abundantly, if the weather be hot and dry, as sometimes is the case, in the early part of the month. This sometimes occurs, however, in conjunction with frosty nights, when it will be found necessary in low damp places to house them early. The first batch of *Zonal Pelargoniums* plunged in ashes should be housed, as should also the earliest set of *Perpetual Carnations* and *Bouvardias*. Advantage should be taken of the present opportunity, before many of the hard-wooded plants are taken in, to prune and tie all climbers, such as *Passifloras*, *Jasminum grandiflorum*, *Clianthus*, *Tecomas*, *Stauntonias*, and *Clematises*. These should have their shoots thinned out and cut away, and after the glass has been washed most of the hard-wooded species may be housed. *Teas* and other climbing *Roses* may also be pruned, and the border should be top-dressed with rich loam and decayed manure.

PITS AND FRAMES.

Pot off *Malmaison* and other winter-flowering *Carnations* that were layered, as advised, last month. Take up *Solanum capsicastrum*, *Callas*, *Bouvardias*, and other winter-flowering plants and pot them afterwards, standing them on a bed of ashes in cold frames, shaded from the sun. *Cinerarias* will also benefit by being shifted into larger pots before they become pot-bound. See that they are shaded from the bright sun, and ventilate freely. Push forward the propagation of all plants required for bedding, as *Heliotropes*, *Coleus*, *Alternanthera*, *Iresine*, *Ageratums*, &c. A good quantity of the scented varieties of *Pelargoniums* should also be put in, as they are very suitable for cutting.

Violets for winter flowering must be put into their permanent positions not later than the middle of the month. This will ensure their getting firmly established while there remains sufficient heat in the soil to induce the formation of young roots. Herbaceous Calceolarias sown last month will now be large enough for pricking out. The sooner this is done the better, to prevent the plants from damping. Tuberoses which have been reared in pits or frames in the summer should be taken into the greenhouse as their flower-spikes appear. Cyclamen should be potted on for a succession, and towards the end of the month another sowing may be made.

FLOWER-GARDEN AND PLEASURE GROUND.

Proceed with the propagation of hardy border plants such as Iberis, Helianthemums, Lithospermums, Dianthus, Phloxes, &c., by taking the young side-growths and inserting them in sandy soil in a cold frame. Where not already done take cuttings of Violas for spring flowering, also Pentstemons, Antirrhinums, &c., for the sooner these are rooted the more surely will they withstand the winter.

Pay attention to tying and staking plants in the herbaceous border that still keep in bloom or have not yet flowered, as the strong winds generally prevalent are apt to break them down. Bulbs of all kinds may be planted when the ground is vacant, but as most beds will still be occupied this may be deferred till next month. Grass on lawns usually grows luxuriantly this month, weeds accumulate rapidly, and leaves are also troublesome; but for the sake of appearances all must be so attended to that the garden may be kept neat and orderly, and thus give rise to a sense of pleasure.

OCTOBER.

PLANT-HOUSES.

Orchid Houses. — As the sun is on the wane, and the outside temperature becomes daily cooler, greater care must be exercised in supplying water to most of the inmates of these houses. A great number of Cattleyas will be at rest, and those which have not yet completed their growth will not, owing to the reduced temperature, require so much water as those growing during the height of summer. All Dendrobes which have made their year's

growth should have a drier temperature, but such kinds as *densiflorum*, *Farmeri*, *thyrsiflorum*, *Hillii*, and others with persistent foliage should not be subjected to a lower temperature than 50° to 55° Fahr.; while such as *Wardianum*, *Findlayanum*, *nobile*, *Ainsworthii*, and other members of that section may be wintered in a house whose atmosphere sometimes falls as low as 45° Fahr. There are not many Orchids in flower in October, but *Dendrobium Phalaenopsis*, *D. P. Schroederianum*, and a few more will be developing their flower-spikes, and will require special attention. *Vanda Amesiana*, *Oncidium tigrinum*, and some few others will still be in bloom. Zygopetalums should be examined for thrips, which are very fond of the flower-buds that will shortly be expanding. Calanthes must be watered sparingly, and the air of the house in which they are growing should be kept rather dry. The present is a favourable opportunity for giving the Orchid houses a thorough wash down before winter, as many of the Dendrobes and other species are dormant in cooler houses. Remove all shingle, gravel, shell, or whatever the stages may be covered with, and wash it in boiling water. This process will destroy any insects which may be lurking in it, and also remove any soil which may have been washed out from the pots.

The temperature of the East Indian houses may be reduced to 65° at night, with a proportionate reduction in the daytime. That of the intermediate house should be 60°, and the cool house 50° to 55°, according to the weather. With this reduction of heat there should be a corresponding diminution in the amount of moisture.

Hothouse. — Cuttings of Croton and other hard-wooded, fine-foliaged plants may still be propagated where a good deal of heat is available. Those rooted now will make nice plants for early spring use. Towards the end of the month cut back Allamandas to within three or four eyes of the preceding year's growth. We do not recommend drying off, but rather the reverse. Various other stove climbers and deciduous plants should now be gradually ripened off, so that they may have a rest for the following two months. Hothouse plants in flower are not numerous. There are, however, a few with brightly-coloured flowers which will be expanding their blooms, including Poinsettias, Plumbagos, and Lasiandras. These should be afforded a little more heat, and fully exposed to sunlight. As the days decline the heat of these houses should be gradually lessened to 65° by night,

with a rise of 10° or 15° by day, under sun-heat. The atmosphere should also be drier, but on no account should it be parched.

Greenhouse and Conservatory.—Any hard-wooded plants which still remain out-of-doors should be housed early in the month. Heaths, Epacris, and other plants of similar nature should be put where there is a free circulation of air whenever the state of the weather permits. Water should be given sparingly, according to the variations of weather, and on fine mornings if possible, to avoid stagnation of the atmosphere. All Chrysanthemums should be housed. The most forward varieties must occupy a space by themselves, and when in bloom should be removed to the conservatory. Pelargoniums of the Zonal type that were prepared for autumn flowering will now be fully in flower, and should have a somewhat dry atmosphere with a temperature of from 55° to 60°, and those which are coming into bloom may have similar treatment. Bouvardias now flowering will thrive in the same house. Fancy Pelargoniums for early flowering should receive their final removal. Till established in the fresh pots water should be sparingly given. Keep a sharp look-out for green-fly, and destroy it on its first appearance.

PITS AND FRAMES.

Bulbs and other plants for forcing should now be potted, including such as Tulips, Hyacinths, Gladiolus (The Bride), *Spiræa japonica*, Lily of the Valley, Solomon's Seal, *Lilium Harrisii*, Narcissus, &c. They should be put into pots of various sizes according to the object for which they are intended. If for cutting, several bulbs may be put into larger pots, but if for the adornment of the conservatory or rooms, then the smaller the pots the better. When potted, all but the latter should be covered with ashes, and these should be placed in a cold frame with Freesias, Alliums, Crocosmos, Scillas, &c. Air should be freely admitted on all favourable occasions to half-hardy plants in cold frames, in order that they may be inured to the weather as far as possible. Pot on herbaceous Calceolarias, Cinerarias, Schizanthus, Cyclamens, &c., as they require it. Insert cuttings of shrubby Calceolarias, Pentstemons, Hollyhocks, and other plants that need the protection of cold frames. Violets for winter flowering should be put in frames if not there already, and any plants which require protection from frost should receive attention without delay.

VOL. I.

FLOWER-GARDEN AND PLEASURE GROUND.

This is one of the busiest months of the whole year, and much depends on the work done during it. Take up and protect from frost any plants that will not withstand the winter, such as Dahlias, Cannas, Fuchsias, Lobelias, Pelargoniums, &c. The beds should also be cleared of all summer bedding plants, and, after being edged and dug, planted with dwarf shrubs, Violas, Wallflowers, Myosotis, Silene, Alyssums, and the like, such plants making a fine display in early spring. When these have been planted, bulbs of various kinds may be dibbled in amongst them, as the flowers of these will stand well up above the carpet beneath. Seed of hardy annuals may also be sown early in the month, for if the winter should prove mild they will bloom before those sown in spring. Lawns should be mown where the grass has a tendency to grow, so that the leaves may be the more easily cleared off. Where alterations are proposed in the ground, or any planting is to be done, the work should be carried out as early as practicable. Trees planted while there is sufficient warmth in the soil to induce quick root action will succeed far better than if the process is deferred till later in the season. There are many evergreen shrubs which do far better when planted in autumn than in spring, therefore no time should be lost in completing the work. Plant deciduous trees as soon as their foliage is matured. Herbaceous borders should be looked over, and where weak plants are overcrowded by stronger ones, the former should be removed to a situation in which they can have more room to develop.

Take up shrubs for forcing and "lay them in", so that they may be potted on the first favourable opportunity. Any plants covering walls, buildings, &c., which require nailing, should at once receive attention to prevent them being broken by high winds.

NOVEMBER.

PLANT-HOUSES.

Orchid Houses.—During the dull days of November, all the inmates of these erections will need special care. Cattleyas that have matured their growth will now be in a dormant state, and those which have not yet attained full development should be carefully watered

and have all the light obtainable. *C. labiata* will now be flowering, and must on this account be carefully attended to, both with regard to water supply and destruction of insect pests. *Lælia albida*, *L. anceps*, *L. autumnalis*, and others will now be displaying their flower-spikes. It is not well to keep them too much on the dry side till the flowers are expanded, or they will be small. The atmosphere of the house in which they flower should, however, be fairly dry, or the flowers will be spotted. *Cœlogyne cristata* that are pushing up their sheaths must have special care, as this is a critical time with them, many of them turning black if too cold or too moist. A temperature of from 50° to 55° at night suits them well. *Maxillaria picta*, *Masdevallia towarensis*, *Pleione Wallichiana*, and *P. humilis*, with some others, will be in flower, and they, combined with *Cypripediums*, *Oncidium*s, and *Zygopetalums*, will make a good display. Many of the *Odontoglossum* family will be in vigorous growth, and some will be sending up their flower-spikes. These should not be neglected, for at this season of the year, particularly if the weather be mild and wet, snails creep into the houses in numbers and soon devour the young tender spikes. Introduce into heat batches of *Dendrobiums* as soon as the flower-buds are sufficiently developed, so that they may be had in bloom early in the new year. The old *Phaius grandifolius* is another useful orchid for cutting, and if a good batch of this is grown, a succession of flowers may be obtained by introducing the plants into heat at various periods.

Hothouse.—Much diligence must be exercised in order to entirely free the plants from all insect pests, during this and the ensuing month. Where it has not already been done, well wash the woodwork and all interior fittings of the houses. Change the shingle or whatever material the stages are covered with, or wash it in boiling water, and, having done this, clean all plants before they are rearranged. Winter-flowering *Begonias* should have liberal treatment, as should also those kept in small pots for decorative purposes. All bulbs, such as *Gloxinias*, *Caladiums*, *Gesneras*, &c., will now be at rest, but a small collection of *C. argyrites* may be started for early use. Pot on Ferns, Palms, and *Asparagus*, and other plants for foliage as they need it, in order that there may be plenty when wanted for ornamentation.

Forcing House.—Towards the end of the month many of the early-flowering shrubs and Roses, that were potted up with the view of having them early in flower, may be introduced into

heat. They should be started in a low temperature (from 50° to 55° Fahr.), and as the buds swell, the heat may be increased, providing the weather is mild enough to admit of free ventilation. Such shrubs as *Spiræa confusa*, *Thunbergia*, *Prunus sinensis flore pleno*, Lilacs, *Deutzias*, *Clematis*, *Azaleas*, *Philadelphus*, *Viburnums*, *Rhododendrons*, and *Roses*, all force admirably if the process is begun in gentle heat. To these may be added such plants as *Spiræa*, *Dielytra*, *Polygonatum* (Solomon's Seal), *Lily of the Valley*, &c. Some of the most forward bulbs may also be introduced, and these, together with *Callas* and other winter-flowering plants, will make a very varied display about Christmas.

Greenhouse and Conservatory.—Very few flowers will now be found out of doors, so that more time and pains must be given to making these houses gay. There should be very little difficulty in achieving this, provided the instructions previously given have been carried out. *Chrysanthemums*, *Abutilons*, Chinese *Primulas*, *Pelargoniums*, *Epiphyllums*, *Habrothamnus*, *Daphne*, Early Roman *Hycinths*, *Narcissi*, *Ericas*, *Salvias*, *Cyclamens*, *Tuberoses* that have been grown in frames during summer, and other winter-flowering plants, should now be at their best, and if they are effectively arranged will be very pleasing. Summer-flowering *Heaths* and New Holland plants should be kept as cool as possible. Ventilate freely whenever the weather permits, and if any mildew appears, at once dust the parts affected with flour of sulphur. Water sparingly when the weather is dull, and if possible do so in the morning, so that the damp may evaporate before night.

PITS AND FRAMES.

These will now be occupied to the fullest extent of their capabilities. *Helleborus niger* (Christmas Rose) should be potted or planted in them, if it is to provide a good supply of flowers about Christmas. In moving these plants get them up with as much soil as possible as they do not like their roots disturbed. *Bouvardias*, to succeed those already in flower, should have weak supplies of manure-water. *Cinerarias*, whose flower-spikes are getting forward, and others that have filled the pots with roots, will need assistance in the same manner. *Violets* will require a free circulation of air on all suitable occasions.

Bulbs such as *Freesias*, *Alliums*, *Lilium Harrisii*, *Tritonias*, *Tulips*, *Crocuses*, &c., should have all the air possible to induce sturdy growth. Stake

Mignonette that is coming into flower, and water with weak liquid manure. Auriculas must be watered carefully, but on no account be allowed to become dry. Material of some non-conducting kind should be put round the outside of wooden frames to exclude frost. Few things are more suitable for this purpose than fresh leaves. If these be placed to the depth of a foot, round the outsides, it will take a very severe frost to penetrate to the frame. Calceolarias and other half-hardy plants should have the lights kept off whenever there is fine weather.

FLOWER-GARDEN AND PLEASURE GROUND.

Finish planting all kinds of bulbs that are intended for spring flowering, not forgetting Ranunculuses, Anemones, *Hyacinthus candicans*, Ixias, Sparaxis, &c. The ground should be covered subsequently with some rough litter to exclude frost. Gladiolus bulbs should be lifted and stored away safe from frost. Sweep lawns and collect leaves for making hot-beds and protecting half-hardy plants from the cold. Push forward the planting of all kinds of trees and shrubs while the weather keeps mild, and before the temperature of the soil is reduced so considerably as to check root action. Any alterations needed in the pleasure ground or shrubberies should now be undertaken, in order that the ground may get settled down again before spring. Plant Roses and protect them from the effects of severe frost by surrounding them with bracken or other rough litter. Lift and protect similarly any half-hardy herbaceous plants or shrubs before severe weather sets in. These include Euonymus, Veronicas, Myrtles, Osmanthus, Desfontanea, Eurya, &c. Dig shrubbery borders and make the whole tidy before frost causes such work to be abandoned in an unfinished condition.

DECEMBER.

PLANT-HOUSES.

Orchid Houses.—The dull and foggy weather prevalent at this season of the year is very troublesome to the cultivator of Orchids, particularly in low-lying districts where fogs are the usual condition. In such places very little damping down of the houses must be practised unless a considerable amount of fire-heat is used to keep up the desired temperature. In the latter case, instead of damping the paths and stages, moisten well the surface round the hot-

water pipes two or three times daily, according to the state of the external atmosphere.

Most of the Cattleyas and Lælias will now be dormant, and a damping down of the houses in which they are situated three or four times a week will be sufficient. In the intermediate section many plants will require moisture to keep them in a healthy flourishing condition. Here the cultivator must again be guided by external influences. In some localities, especially on elevated ground in exposed situations, where the soil is naturally dry, there is far less humidity in the atmosphere. Where such is the case it is almost impossible to avoid aridity, especially if the surface within the houses is non-porous. For Odontoglossums we advocate the use of tanks running underneath the stages the whole length of the structures, and if the hot-water pipes are placed side by side over these there is no surface to dry. It is far better to reduce the temperature of the houses two or three degrees than to have a parching heat. If canvas were fixed on rollers so that it could be let down in severe weather the difference to the inside temperature would be very great. With an equal amount of artificial heating the house would be at least ten degrees warmer. The great drawback to such coverings, however, is that they often get frozen to the rafters and cannot be rolled up till it has thawed.

Hothouse.—Where much indoor decoration has to be done a batch of Caladiums should be grown on for the purpose, as no better decorative plants can be found than some of the dwarf varieties.

Continue to propagate Coleus, Acalyphas, and other plants of that class which are easy to cultivate to supply plants for decorating. December is not a month when we may expect to see many hothouse plants in flower; still, there should be a quantity of the winter-flowering section of Begonias in bloom. These, together with such things as *Euphorbia jacquiniæflora*, Epiphyllums, Rondeletias, Scutellaria, *Thyrsacanthus rutilans*, Sericographis, &c., will make a brilliant show, intermixed with other fine-foliaged plants. Most of the plants in this department will now be at rest, therefore the temperature of the houses should be kept as low as is safe, so that the plants may not be unduly excited too early. Potting material of all kinds should be brought under cover, and, if possible, put into a temperature quite as high as that in which the plants are growing, in order that it may be ready for use when required.

Greenhouse and Conservatory.—One

of the greatest obstacles with which a gardener has to contend in the case of Conservatories adjoining a dwelling-house is the frequent opening and shutting of doors at this period of the year, where there is a passage through from one to the other. Too much care cannot be exercised in this case when the air externally is a number of degrees below that of the house. Plants suffer more from a sudden draught and cutting winds than from a persistent low temperature. It is far preferable to have a porch and double doors to such places in order that the outer doors may be closed before the inner are opened. These structures should also have sufficient hot-water pipes to keep them at the requisite temperature without the necessity of heating them to such an extent as to cause a drying atmosphere. Nothing is more unpleasant than the smell of over-heated pipes. They have also a very injurious effect on the plants. Ventilate cautiously when frosty winds are prevalent, and see that the plants are not subjected to cold draughts.

Forcing House.—Continue to introduce plants into heat as may be necessary to keep up a succession of bloom. It is not advisable, however, to take them from a cold frame or pit and to place them in a strong heat all at once, as this process has often a tendency to cause the buds to fall. Such plants are best brought on steadily, and for this reason require a moderate heat to commence with. Hyacinths, Tulips, and Narcissus started now will bloom far better than those introduced into heat last month. Great care must be used in hardening all such plants before they are taken to the Conservatory or Greenhouse.

PITS AND FRAMES.

Violets will now require particular attention. If the weather be severe enough to prevent the removal of the lights for any length of time, take advantage of the first favourable opportunity to give air, or the buds will damp off. No good is obtained by uncovering frames when

the temperature in the open is several degrees below freezing-point, as that inside these structures will also be abnormally low. Therefore unless some of the plants are showing flower, no harm will be done to them if they are not uncovered for a month, or so long as the frost lasts. As soon, however, as a thaw occurs, the covering should be removed and air gradually admitted till the plants are inured to the outside temperature. Be careful in watering any inmates of pits and frames, giving sufficient only to prevent flagging. Some of the more hardy occupants, such as border Carnations, Brompton and other Stocks, Hollyhocks, Violas, &c., will take no harm if exposed to one or two degrees of frost. Better to be so exposed than to be coddled.

FLOWER-GARDEN AND PLEASURE GROUND.

Whenever the weather remains open push on with the planting of all kinds of deciduous trees and shrubs, as the sooner they are planted the better. Look over flower-beds that were planted last month, and pick up leaves and other litter that may have got lodged there by the wind. Rake out leaves from amongst shrubs and dig over the borders, so that they may present a tidy and well-kept appearance. Should the weather be frosty, wheel on manure and turn over any refuse heaps, in order that the contents may be thoroughly decomposed before wheeling it on to the ground. Examine drains and see that no gravel has been washed into them by heavy rain. Clean out cesspools and water tanks that have become stagnant, so that the latter may get filled again before spring. Re-gravel walks where necessary, and turn others that have become green or mossy. Any alterations needed in the way of relaying turf should be proceeded with during mild weather, so that the ground may be settled down by spring. Prune and train creepers to walls and fences. Protect half-hardy plants from frost, and in bad weather make a sufficient quantity of labels to name plants as they are planted out. [H. C. P.]

METEOROLOGY.

No class of men take such a keen interest in the weather as gardeners, and very naturally, considering how greatly the success of the plants under their care depend upon favourable atmospheric conditions. Besides which, being so constantly in the open air, few men watch the

erratic movements of that fickle element more closely. It is no doubt owing to this constant watchfulness that gardeners are so often capital judges of coming weather. They will, however, find their efforts in this direction greatly assisted by making regularly a few simple observations

with meteorological instruments, to say nothing of the interest that every tiller of the soil takes in comparing one season with another, which can only be done with any degree of accuracy by the aid of a neatly-kept weather record.

The meteorological instruments necessary for a well-ordered garden need be but few in number. They are as follows: a barometer, a maximum and a minimum thermometer, a thermometer sunk in the ground to give the temperature of the soil, and a rain-gauge. All the readings should be taken, and the instruments set, at a certain fixed hour, the most suitable being 9 A.M. The observations should be entered in a pocket note-book each day in the same order, and afterwards copied into a proper meteorological register,¹ or any other suitable book having lines ruled for the purpose. When once the observer is able to take the observations with ease, he will find that they will occupy less than ten minutes of his time each morning.

The Barometer.—There are many forms of this instrument, but the best for the purpose is that known as the pediment barometer (fig. 1). A sufficiently good one may be obtained for about 25s. Like all other weather instruments, great care is necessary in selecting a suitable position for it. It may be suspended in any room not exposed to sudden changes of temperature. It must not be near a fire or stove, or where the sun can shine directly upon it. On the other hand, it should be in a good light, and at a convenient height from the floor for reading its indications easily.

The scale will be found to be divided into inches and tenths of an inch. In order to take a reading, turn the button beneath the scale until the index-pointer attached to the bottom of the vernier is just level with the top of the mercury in the tube. By the vernier is meant a narrow vertical plate with divisions upon it, apparently similar to those on the scale of the

barometer, which, by means of the button referred to, can be made to slide up and down the face of the scale. The object of the vernier is to enable the observer to read correctly to hundredths of an inch, which it would be impossible to do with the unaided eye. Having adjusted the vernier, notice the division on the scale of the instrument next below the bottom of the vernier. Suppose this to be 29·3, or 29 inches and 3 tenths. Then look along the vernier until one of its divisions is seen to be in the same line with a division on the scale. Should this be 2, as in fig. 2, then the reading

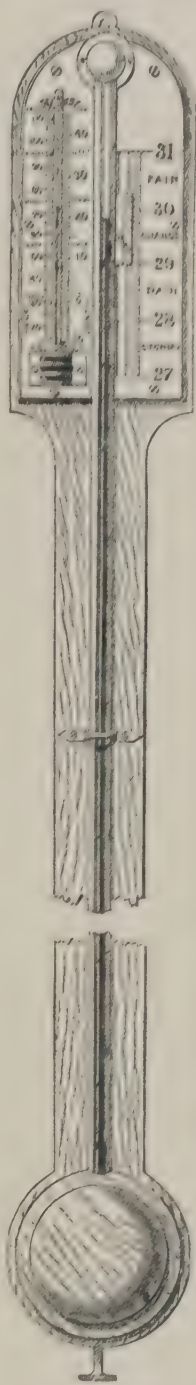


Fig. 1.—Pediment Barometer.

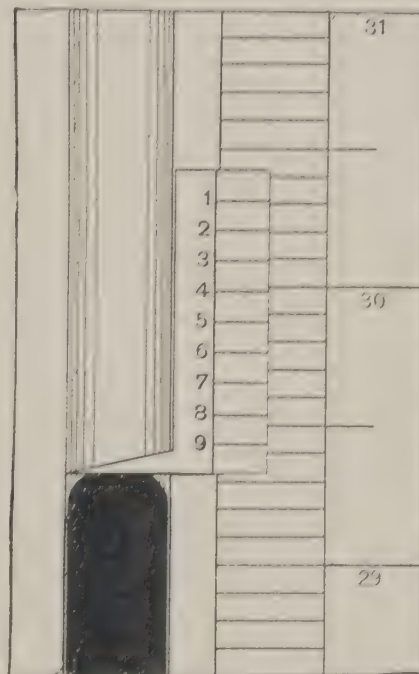


Fig. 2.—Vernier of Barometer.

will be 29·32 inches, or 29 inches, 3 tenths, and 2 hundredths of an inch.

The barometer, as its name implies, is an instrument for measuring the weight or pressure of the atmosphere. It is popularly known as a “weather-glass”, because alterations in the weight of the air are so often accompanied by changes in wind and weather. As indicating coming weather, it is not so much the actual height of the mercury at the time that is to be noted, as the change in level which has taken place since the last observation was made. If the rise be gradual, the fine weather which follows is likely to last longer than if it be a sudden one. In the same way a gradual fall indicates, as a rule, continued unsettled weather, while a rapid dip shows rough weather of short duration, making good the lines:

“Long foretold—long last,
Short notice—soon past”.

When the mercury has been unusually low and begins to rise again, there is nearly always a

¹ Symons's blank Meteorological Register may be obtained of E. Stanford, Cockspur Street, London, S.W. Price 2s.

considerable increase in the strength of the wind. In other words,

“First rise after very low
Indicates a stronger blow”.

During the winter months the rise of the barometer almost invariably shows the approach of colder weather,¹ whereas a fall is nearly always followed by milder temperatures than those which have recently prevailed.

Thermometers.—In order to obtain the temperature of the air, only two of these will be necessary—a maximum thermometer to show the greatest heat during the daytime, and a minimum thermometer to show the greatest cold at night. The maximum thermometer selected should be what is known as a “Negretti & Zambra” maximum, while the minimum thermometer should be a “Rutherford” minimum. Sufficiently accurate and trustworthy instruments of both kinds can be obtained for about ten shillings each. The divisions should be marked on the glass tube itself, as well as on the porcelain scale on which the thermometer is mounted.

Some form of shelter from sun and rain must be provided for these thermometers or their indications will often be unreliable. A simple and effectual screen may be made as follows. First select an open position on a lawn on which to place it. For it must not be under trees, nor within 20 feet of any wall. The screen should be supported by two posts, as shown in the accompanying illustrations (fig. 3). After having been driven firmly into the ground these posts should each stand 5 feet above the lawn. To the upper part of these posts fasten by screws a half-inch board 1 ft. 10 ins. wide by 1 ft. deep, which, when in position, must face due north. At right angles to this board, at each end, there should be two side pieces of the same thickness and 9 inches wide, to protect the thermometers from the morning and afternoon sun. Then, in order to prevent their readings being affected by the heating up of the back-board at mid-day, let another half-inch board be fixed an inch in front of the other one, so as to secure a space for air between the two boards. The second board should be screwed at the ends to the two side pieces. Let a sloping roof be provided to keep off the rain, and this simple form of screen is very nearly complete. All that remains is to drill three holes an inch in

diameter near the top of the second board and just under the roof, to ensure the ventilation of this part of the screen, and a similar hole in each of the side projections, where indicated in the section (see fig. 3), to ventilate the air-space

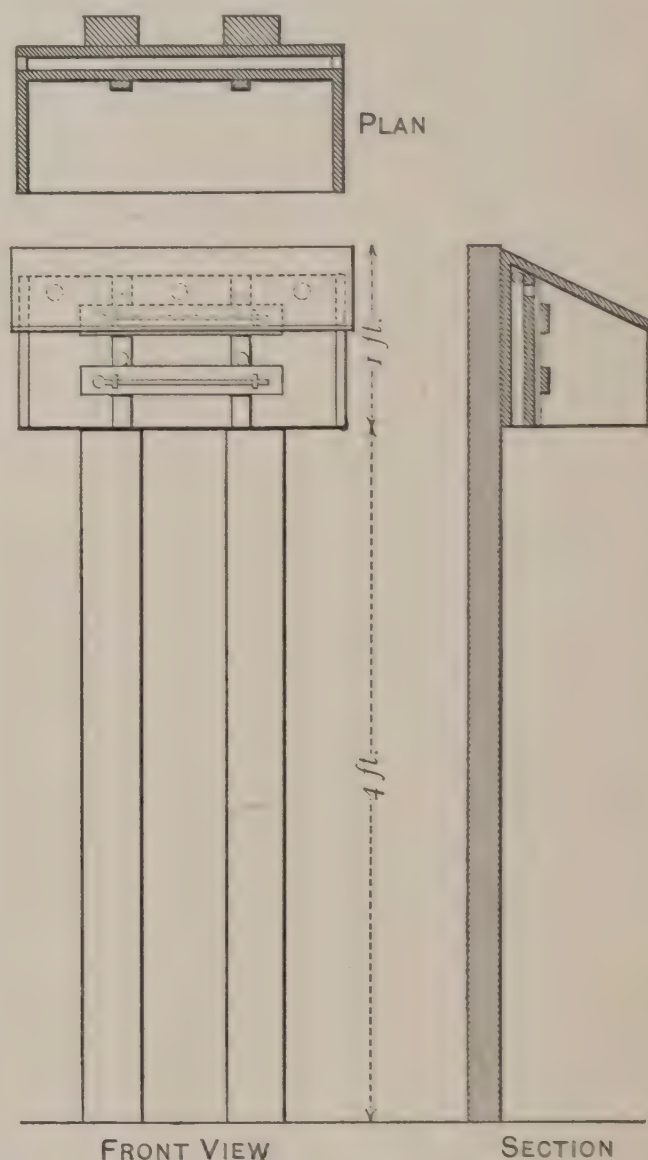


Fig. 3.—Thermometer Screen.

between the two boards. The thermometers should not be suspended from the second or north board itself, but from two vertical strips of wood an inch wide and half an inch thick fastened to it. The strips should be in the centre of the board, and a sufficient distance apart to suit the holes in the brass plates attached to the backs of the thermometers. When finished, the whole of the screen should be painted with three coats of white paint. Any carpenter could make this screen with the aid of the accompanying illustrations and foregoing instructions. The total cost should not exceed 20s. Both thermometers must be suspended horizontally by means of brass screws, and the maximum thermometer 2 inches above the minimum.

In reading the maximum thermometer (fig. 4), the exact position of the end of the mercury should be noted and entered in the observation

¹ In some districts severe frost occurs with barometer at 29.50 to 29.80, and if the barometer rises there to over 30 ins. but little frost is experienced.—ED.

book to the nearest degree. For example, if nearer 56 degrees than 57 degrees, it should be entered as 56 degrees. To set the instrument, remove it from the screen and hold it bulb downwards, at the same time shaking it gently

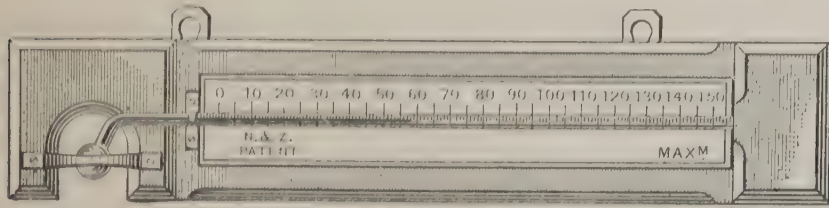


Fig. 4.—Maximum Thermometer.

until there is a continuous thread of mercury throughout its length. In this form of maximum the tube is contracted near the bulb in such a way that when the mercury expands it can flow past the narrowed passage, but cannot return into the bulb until shaken down by the observer when setting it. The minimum thermometer (fig. 5) is a spirit thermometer. In

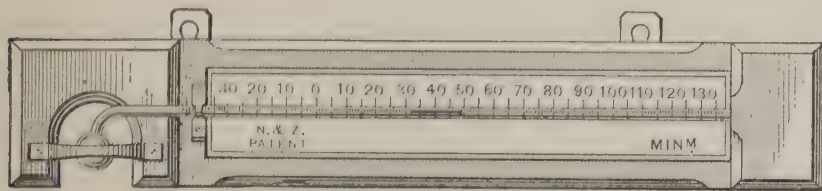


Fig. 5.—Minimum Thermometer.

the thread of spirit will be found a little metal index, which will allow the spirit to flow past it without moving when the temperature is rising; but with a falling temperature the spirit carries down the index with it as soon as the end of the spirit reaches the upper end of the index. In taking a reading, enter in the observation book the temperature indicated by the end of the index farthest from the bulb to the nearest degree. Then, in order to set the instrument, remove it from the screen and tilt it, bulb upwards, so as to allow the index to run down to the end of the spirit. When properly set both thermometers should read alike, at all events to within about a degree, and it is always advisable before leaving them that the observer should see that they do so. The temperature of the air may at any time be ascertained by reading the end of the spirit in this thermometer.

Spirit thermometers are unfortunately liable to a serious defect. Some of the spirit occasionally evaporates and becomes condensed in the upper part of the tube. So that until the evaporated spirit is returned to the main thread the thermometer will continue to read too low. It is owing to inattention to this source of error,

or through not being aware of it, that the temperature records of gardeners in times of extreme cold are so often unreliable. As much as 10 degrees of spirit have been known to become lodged in the upper part of a thermometer tube. An extreme case like this only shows what erroneous readings may be quoted, for, as will readily be understood, 2 degrees of frost at once becomes 12 degrees of frost, 12 degrees of frost 22 degrees, and so on. And until set right, each reading would continue to be as much in error. If after both thermo-

meters have been set, the minimum thermometer is found to differ from the maximum more than about a degree, the end of the tube of the former must be examined, and should any spirit be detected there the instrument should be set right. This can be done by holding the thermometer securely in one hand by the end farthest from the bulb, and swinging it sharply downwards at arm's-length, taking care of course in doing so that it swings clear of surrounding objects. This plan, with a little patience, will compel the detached portion of spirit to rejoin the main thread. The thermometer should afterwards be placed, bulb downwards, in a cool place for an hour or so to complete the cure.

Spirit thermometers exposed to the direct rays of the sun are very much more liable to get out of order in this way than those sheltered at all times from it. Hence the great advantage of placing them on a screen such as has been previously recommended.

The reading of the maximum thermometer should be entered to the *previous* day, and that of the minimum to the day on which the observation is made. Whenever the divisions on the glass tube of either thermometer become indistinct, they can easily be renewed by rubbing the point of a lead pencil along the tube when dry. There are during the year certain marked periods of unseasonably cold weather, which occur with more or less regularity. Of these the most noteworthy is a cold period between the 9th and 14th of May, and another between November 6th and 12th.

Earth Thermometer.—A very simple and easy method of ascertaining the temperature of the soil is by means of one of Symons's earth thermometers.¹ It consists of a stout iron pipe drawn out at the bottom to a point, and driven

¹ A Symons's earth thermometer for a depth of one foot can be obtained of Mr. L. P. Casella, 147 Holborn Bars, London, E.C. Price 21s.

into the ground to the required depth. Into this tube a thermometer is lowered, and the top closed by means of a copper cap. An open position on a lawn should be chosen for this instrument. The best depth is one foot. The thermometer should be drawn up when an observation is taken, and read to the nearest degree. The reading should be entered to the same day as that on which it is made.

Rain-gauge.—The most useful form of rain-gauge for a garden is one made of galvanized iron. It has a deep rim, and is 5 inches in diameter.¹ An open position on a lawn should be selected for it, away from trees, walls, or buildings—at the very least as many feet from their base as they are in height. It should be secured in position by four stakes firmly driven into the ground round it, as shown in fig. 7. The top of the rim should be one foot above the ground, and must be quite level. Each morning the gauge should be examined, whether any rain be known to have fallen or not. If any water be found in the receiving bottle or can, it should be emptied into the glass measure supplied with the gauge. When a reading is taken the measure should be quite vertical, and the nearest division to the height of the water in it noted, and the amount entered in the observation book to the *previous* day, and not to the day on which the measurement is made. Each of the short divisions represent $\cdot 01$ inch (or a hundredth of an inch), the longer divisions $\cdot 05$ inch (or five hundredths of an inch), and the long divisions having figures attached $\cdot 10$ (or tenths of an inch). For instance, the amount indicated in the measure shown in fig. 8 would be two tenths of an inch (or $\cdot 20$ inch). As the glass measure is graduated to hold only half an inch (or $\cdot 50$ inch), in order to measure a heavy fall of rain two or more readings will have to be taken. Say, for example, if the first measurement made be $\cdot 46$ inch, the second $\cdot 43$ inch, and the third

$\cdot 28$ inch, the three should be added together and the entry made as $1\cdot 17$ inch (or one inch, one tenth, and seven hundredths of an inch).²

In times of snow, measure off in the glass measure sufficient warm water to melt the snow collected in the funnel of the gauge. Make a

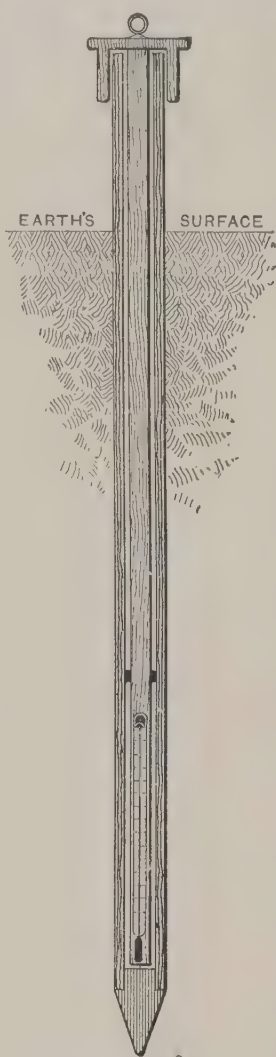


Fig. 6.—Symons's Earth Thermometer.

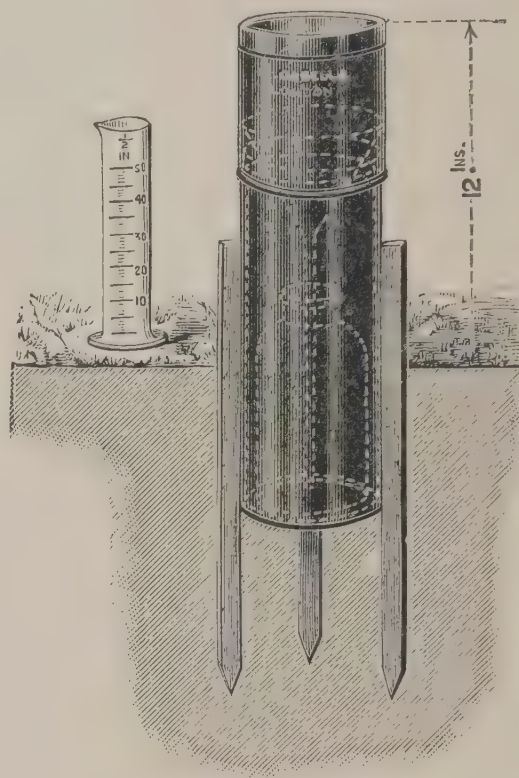


Fig. 7.—Rain-gauge (Snowdon pattern).

note of the measured quantity of warm water, and then pour it upon the snow in the funnel. Next measure the water found in the receiving vessel, and afterwards deduct from this measurement the quantity of warm water which had been added to melt the snow. For example, suppose the warm water to have measured $\cdot 45$ inch, and the water, including the melted snow, found in the receiver $\cdot 76$ inch, then the entry made in the observation book should be $\cdot 76$ inch less $\cdot 45$ inch (or $\cdot 31$ inch). In a deep fall of snow, where the funnel is not large enough to hold the quantity deposited, measure with a rule the average depth of the snow on the ground, and take one-twelfth as the equivalent of water which it would yield when melted.

For instance, suppose the rule measurement to be 10 inches or $10\cdot 0$ inches, divided by 12 this would give $\cdot 83$ inch as the amount to be entered in the observation book. This latter plan, however, should not be



Fig. 8.—Rain-gauge Measure.

¹ This gauge is made by Negretti & Zambra, Holborn Viaduct, London, and its price, with measure, 12s. 6d.

² Application should be made to Mr. G. J. Symons, F.R.S., 62 Camden Square, London, N.W., for his "Arrangements for the Systematic Observation and Record of the Rainfall of the British Isles", which will be sent free of charge.

adopted if the former be available, as it is only a roughly approximate estimate of the actual measurement.

Wind.—The direction of the wind may be taken either from a wind-vane or from the drift of smoke from chimneys. It will only be necessary to enter the direction in the observation book for one or other of the following eight points of the compass, viz.: N., N.E., E., S.E., S., S.W., W., and N.W. A change of wind “with the sun” (veering N. to E., E. to S., &c.) is a general indication of fine weather, but a change “against the sun” (N. to W., W. to S., &c.) as a rule indicates rainy and unsettled weather.

In the foregoing instructions an endeavour has been made to render them as simple and practical as possible, and at the same time to recommend instruments as inexpensive as is compatible with accuracy sufficient for the purpose for which they are required. The total cost of the equipment, including barometer, thermometers, thermometer screen, and rain-gauge, need not exceed £5.

All the instruments (barometer excepted) must be set up in the most open position available in the garden, and over short grass. Care should be taken that they are always kept in good working order. For instance, the minimum thermometer must be put right at once should

it not agree with the maximum when both are set. The rain-gauge must be always firm and level, and the receiving vessel and measure occasionally cleaned. The observations must be taken regularly at the same hour each day. It will be found far more satisfactory and interesting to take a few observations which can be relied upon, than any number either with indifferent instruments or with those indifferently situated.

Where observations are required which will be strictly comparable with those made at properly ordered meteorological stations in other parts of the country, a more expensive set of instruments will be necessary.¹ For a description of these, and complete instructions how to observe them, the reader cannot do better than consult *Hints to Meteorological Observers*, issued by the Royal Meteorological Society, and obtainable of E. Stanford, Cockspur Street, Charing Cross, London, S.W., price 1s. *Elementary Meteorology*, by Robert H. Scott, F.R.S. (Kegan Paul, Trench, & Co., 1 Paternoster Square, London, E.C.), price 5s., will be found an excellent text-book on the science of meteorology. [E. M.]

¹ A model set of meteorological instruments for garden equipment can now be seen in the Royal Horticultural Society's Gardens at Chiswick, on application to the secretary, 117 Victoria Street, Westminster.

THE GARDENER'S ASSISTANT

CHAPTER I.

PLANT STRUCTURE.

CONDITIONS OF EXISTENCE—STRUCTURAL ELEMENTS—
THE CELL AND ITS CONTENTS—PROTOPLASM—MODI-
FICATIONS OF CELLS—PITTING—THE THALLUS.

THE gardener has to deal with those living beings which are known as plants. The life of a plant and its fundamental construction are, broadly speaking, identical with the life and with the construction of an animal. It is not necessary here to point out in what minor particulars plants differ from animals; all that is necessary at this stage for the gardener to realize is the fact that a plant is as much a living creature as an animal. It has to exist, to grow, to reproduce itself. It does all these by availing itself of the circumstances in which it is placed and by utilizing the materials which surround it. Work of this character could not be carried on without machinery, and this machinery is supplied by the structural elements of which the plant, like the animal, is made up.

To enable the plant to maintain itself, to grow and develop, it requires to be placed within a certain range of temperature which must be neither too high nor too low; it requires food, or substances capable of conversion into food, and these substances are derived from the water in the soil or from the atmosphere. It requires, in fact, to breathe, to feed, to exhale, and to be protected against adverse conditions. Special conditions come into play when the plant reproduces itself. Hence it is that a plant has to be considered not only for itself, but also in relation to its surroundings and to the conditions of its existence—in relation, that is, to heat, light, air, water, and soil. The physiologist in the laboratory can study the effects, say, of light apart from those of heat, but the gardener never has the chance of studying the plant in this simple manner. He has to study it as it grows in nature or under cultivation, subjected to the

combined and simultaneous influence of diverse, and it may even be conflicting causes. In a wild state the plant has more or less power of adapting itself to these varied conditions, more or less means of resisting adverse influences of all kinds. If its powers of adaptation and resistance are sufficient, the plant will thrive and multiply. If, on the contrary, its endowments are inadequate, the plant will gradually dwindle, be elbowed out of existence by its better-endowed competitors, or become the prey of parasitic enemies.

Under cultivation the plant is, so far as possible, removed beyond the reach of its enemies, and it is, or should be, placed under the most favourable conditions, so that it may become a "model of good cultivation". It must not, however, be overlooked that the qualities that gardeners prefer and seek to develop are not always those which are best for the plant itself. The plant's necessities and our requirements are not by any means always identical, so that it very often happens in cultivation that we do what is best for ourselves, but not that which is best for the plant, and we succeed in producing a monster or a deformity, where Nature, left to herself, would have produced something quite different. Compare, for instance, a broccoli with the wild cabbage. But, in any case, the general principles of cultivation are the same, even though in practice we have to modify them to suit our requirements or the exigencies of circumstances.

From what has been said, it is evident that we have, first, the plant and its structure to consider; then the conditions under which it is placed—the "environment", as it is called; and lastly, the way in which the plant turns to account the conditions by which it is surrounded, and the influence of those conditions separately and in combination. To carry out such a programme fully the student must needs be at one and the same time a botanist, a microscopist, a chemist, a physicist, and a physiologist.

Gardening as a practical art must be learnt practically; but the more practice is learned with and guided by knowledge and trained intelligence the better will the practice be. Intelligence may be cultivated in various ways, but it stands to reason that the intelligence of the gardener should be exercised in the study and consideration of the objects he is expected to deal with. It is not desirable, even if it were possible, that a gardener should be an expert in all, or even in any one, of the branches of knowledge before mentioned, but he should certainly have such a general acquaintance with them as will enable him to appreciate their bearing upon his daily practice. This will permit him to avail himself of the resources which the scientific man is constantly placing at his disposal, and will enable him not only to maintain the standard of horticultural excellence, but to promote its advance—an advance that practice of itself will never enable him to accomplish.

THE CELL AND ITS CONTENTS.

Like all living creatures plants grow from very small beginnings. The *cell* of which we are about to speak is not the actual beginning, but, for convenience sake, we here take it as our starting-point. A cell in appearance is a very simple thing (figs. 9, 10, 11), though it is usually so small as to be invisible to the naked eye.



Fig. 9.



Fig. 10.



Fig. 11.

Isolated Cells (figs. 9 and 10) with and (fig. 11) without Nuclei—highly magnified.

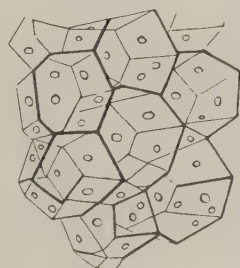


Fig. 12.—Elder Pith, consisting of aggregations of Cells—magnified.

But in a piece of elder-pith (fig. 12), or, better still, in the pulp of the orange, it is easy to see that the spongy substance of which either consists is made up of cells. They look like little bags or bladders of membrane, containing fluid and other contents. The complete cell consists of a membranous bag, or *cell-wall* as it is called, and of various contents, the most important of which is a viscous substance, found invariably in all living cells, and which is called *protoplasm*. This is colourless, and hence is not easily seen even under the microscope till its presence is made obvious by the addition of acids, which cause it to shrink and separate from the cell-wall, or by the use of colouring matters (dyes), which alter its texture and colour, and

render it conspicuous. Thus a solution of hæmatoxylin (the colouring matter of logwood) stains both the cell-wall and its contents, but in different degrees. Carmine stains the protoplasm

and its contents, but leaves the wall uncoloured, or only faintly tinged. Nitric acid and ammonia stain the protoplasm a bright yellow. To the chemist this change of colour indicates the presence of nitrogen.

The cell-wall consists of a substance known as *cellulose*, a substance containing no nitrogen, but nearly allied to starch, and, like it, coloured blue when treated with iodine and sulphuric acid. In a young condition, and when not thickened by deposits on its inner surface, it allows of the passage of watery fluids through its texture into the interior of the cell.

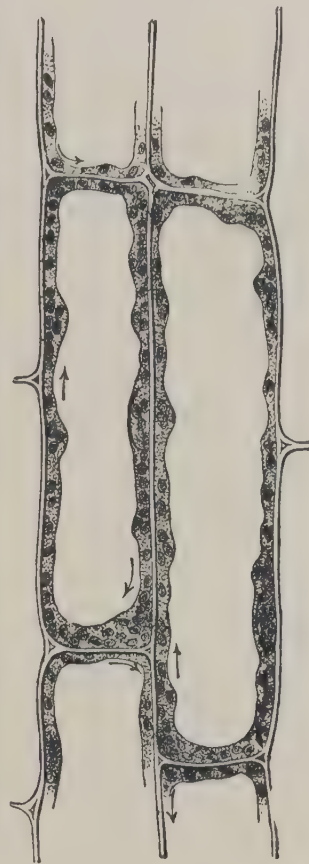


Fig. 13.—Protoplasm in motion, in the direction of the arrows—*Vallisneria*

The protoplasm is in all ways the most important part of the cell, the bag or cell-wall which incloses it being merely of a protective nature. The protoplasm is sensitive to impressions, now contracting, now diffusing itself, according to circumstances, and often endowed with powers of motion (fig. 13). Moreover, it can, and does sometimes, exist by itself. The living cell-wall, on the other hand, cannot maintain an independent existence. If it occurs, as it does sometimes, without protoplasm, it is as a mere dead shell endowed with physical, but destitute of vital, properties.

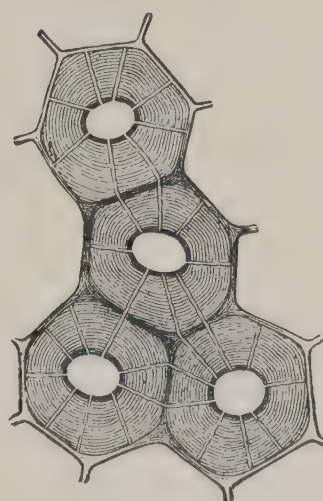


Fig. 14.—Section across Wood-cells, showing concentric layers of woody matter surrounding a central cavity—*Scolopendrium*.

Every living cell thus constituted of protoplasm and cell-wall has, or may have, in the protoplasm, at some period of its existence, a small, relatively hard, highly-refracting body called the “nucleus” (figs. 9 and 10), which, when the cell is dividing, undergoes a series of most remarkable changes and plays a

most important part in the growth and development of new cells from the old, but which for our present purpose we may pass over with the mere mention. One such cell as we have mentioned may constitute the entire plant; the plant and the cell are one and the same, so that in that

case all the business of life is carried on in that one cell.

Usually, however, plants consist not of one, but of a large number of cells in association (fig. 12). Just as a house is made up of bricks, so a plant is made up of cells. There is, however, this

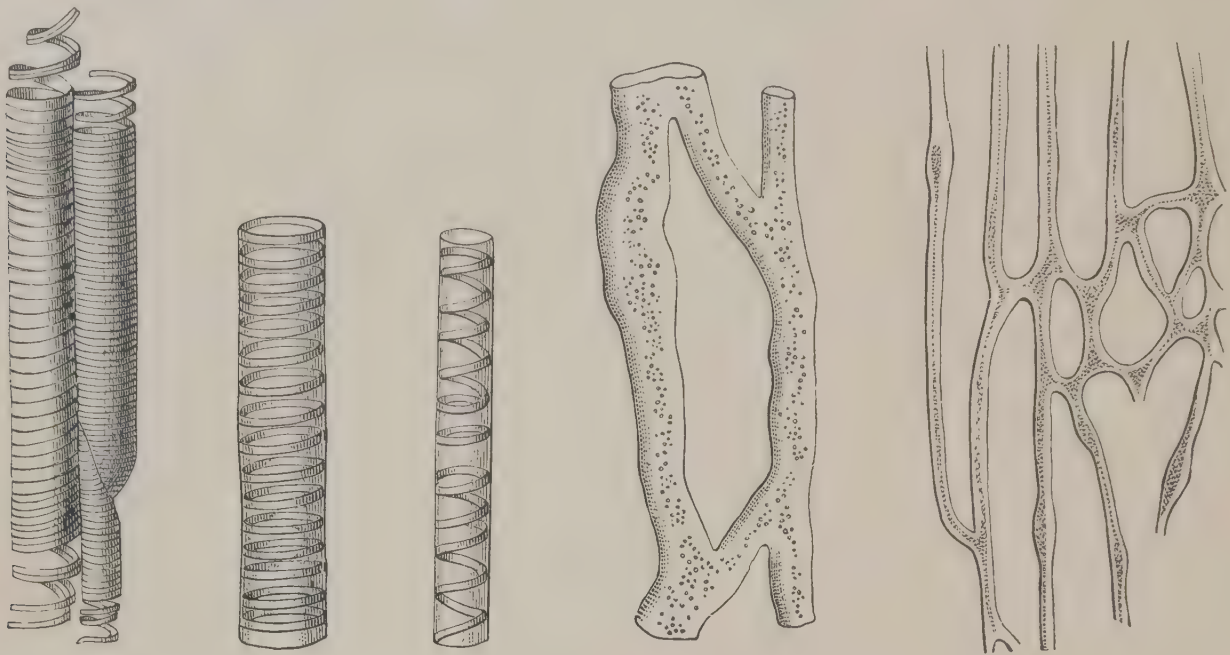


Fig. 15.—Melon—Spiral Vessels.

Fig. 16.—Annular Vessels.

Fig. 17.—Spiral and Annular Vessels.

Fig. 18.—Celandine—Laticiferous Tissue.

Fig. 19.—Dandelion—Laticiferous Tissue.

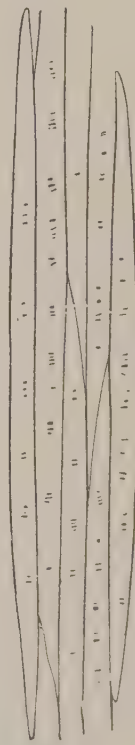
important difference: the bricks are dead things, but the cells, at least in the young state, are full of life. They feed, they grow, they breathe, they secrete, they manufacture substances requisite for the nourishment of the plant at a future time, they store up those substances till they are required, they increase in size, and they multiply.

Some plants, like the simplest Algæ and Fungi, consist of cells, and cells only, that is to say, of cells that are little if at all modified in course of growth. Generally speaking, however, as the work of the plant becomes greater and more complex, and as the outside conditions vary, so the nature of the cell alters also.

The most common change is a thickening of the cell-wall by deposit on its inner surface (fig. 14). The object of this is to confer strength and power of resistance, and, sometimes, to protect soft tissues in the vicinity from injury. The thickening layers may be very thin, or they may be so thick as nearly to fill up the original cavity of the cell, as shown in the accompanying illustrations.

In form, also, the cell varies greatly; originally globular, it becomes compressed by its neighbours, and so assumes a polygonal form (fig. 12). Almost invariably some of the cells lengthen into tubes (fig. 20), these tubes being often irregularly thickened, so that thin interspaces exist between the thickened portions,

whilst not unfrequently the deposit takes the form of a spirally-twisted thread or threads (figs. 15, 17). The tubes just mentioned are of two distinct characters. In the one case they consist of single cells lengthened out, when they are called, if thickened, wood-fibres or *tracheids* (figs. 20–22); in the other case the tubes are of composite origin, resulting from

Fig. 20.
Tracheids.Fig. 21.
Fibres.Fig. 22.
Pitted Tracheids.

the placing of cells in one line, end to end, and the breaking down of the partitions between them, so that a continuous tube or *vessel* is formed (figs. 15–19).

The mass or substance of a plant is spoken of as *tissue*; if of unmodified cells, the tissue is cellular; if of vessels and fibres, it is called fibro-vascular tissue (fig. 23). The most simply

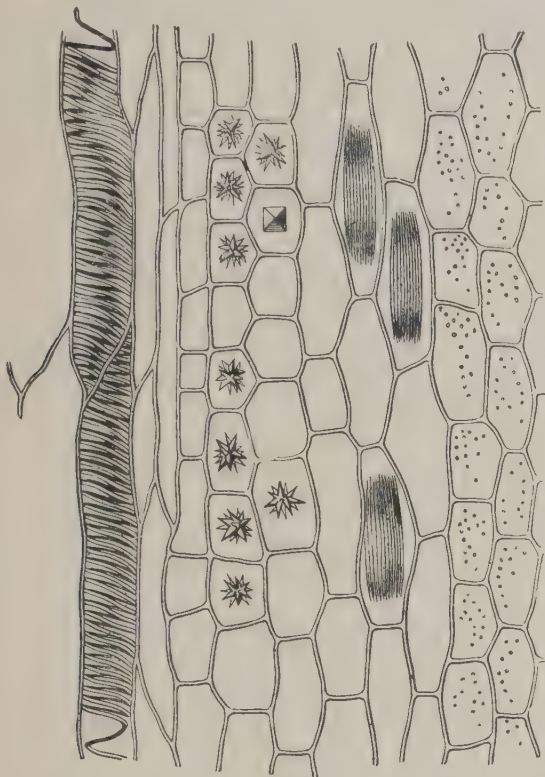


Fig. 23.—Cut illustrating various tissues. To the left Spiral Vessels, followed by long Conducting Cells. These are succeeded by Cellular Tissue or Parenchyma. In some of the square cells are Crystals of Oxalate of Lime. In the longer cells are groups of Needle-like Crystals called Raphides. To the extreme right are Pitted Cells.

constructed plants are those consisting of one cell, which may be either simple or branched. Next come plants that consist of many cells associated into a tissue; and then those in which vessels are found together with cells. Those plants that have no true roots, leaves, or flowers, are *cellular plants*, devoid of vessels in their composition. Those plants that have well-marked roots, leaves, or flowers, have also

vessels, and are hence called *vascular plants*, such as a fern, a lily, or an oak. So that a mere glance, without a microscopical examination, is generally sufficient to enable the observer to know whether he is looking at a cellular or at a vascular plant.

THE THALLUS.

The aggregation of cells to form an individual plant is termed a *thallus*, and those plants which consist wholly of cells are termed *Thallophytes* or *Thallogens*. The thallus may consist of long threads or *hyphæ*, simple or variously branched, as in the spawn of a mushroom; or it may consist of flat plates of leaf-like appearance and texture, as in many sea-weeds. [M. T. M.]

CHAPTER II.

THE LIVING PLANT.

GREEN PLANTS—UNCOLOURED PLANTS—PARASITES—SAPROPHYTES—MICROBES—SYMBIOSIS—THALLOPHYTES AND VASCULAR CRYPTOGAMS—ASEXUAL AND SEXUAL CONDITIONS—FLOWERING PLANTS—SENSATION AND MOVEMENTS IN PLANTS—CONTINUITY OF PROTOPLASM.

The plant, then, is unicellular or multicellular, and if its structure remains thus simple it is a *Thallophyte*. If some of the cells grow into vessels it becomes a *vascular plant*. Plants may also be distinguished into two groups, those which do not, and those which, under the influence of light and heat, do form a green substance in their cells, this green substance being in the form of granules, often varied in

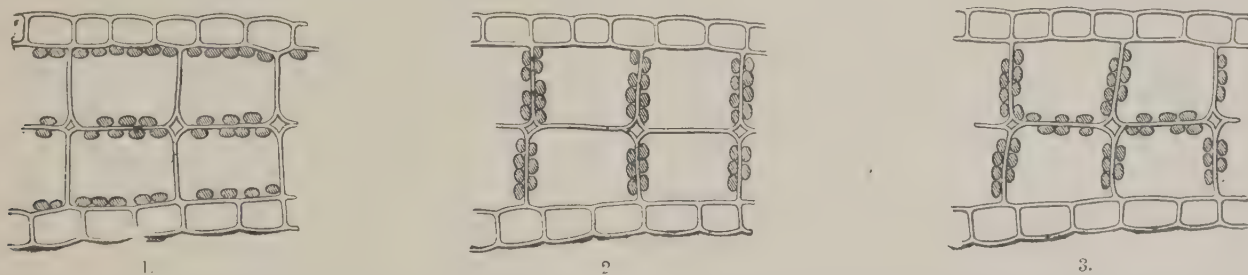


Fig. 24.—The woodcuts show the appearance of a section through the Common Duckweed, *Lemna trisulca*. Above is seen an Epidermis of square cells, without Chlorophyll; beneath is seen a similar layer constituting the Lower Epidermis or Skin. Between the two skins is the Cellular Tissue, consisting of two layers of large square cells in which the Chlorophyll Granules are differently arranged, according to the direction and intensity of the light: 1, in darkness; 2, in direct sunlight; 3, in diffused light.

position according to the direction of the light, and technically known as *chlorophyll* (fig. 24).

Green Plants.—It is the green plants that are the most highly organized and with which the gardener has most to do. The green plants pursue an independent existence, work for themselves, obtain their own food-supplies, elaborate them to supply their own requirements, use up some at once, store up others for future consumption.

Colourless Plants.—The colourless plants are far less independent. They cannot manufacture their food from the raw material, they must get it ready made, hence they are *parasites*, living on the juices of other plants, or they are *saprophytes*, availing themselves, for food, of the decaying or dead tissues of other plants or of animals. They may hence serve a useful purpose as scavengers. There was a time when

these organisms were looked down upon and spoken of as "lower" plants, and, so far as structure and organization go, they really are less highly endowed than are the green or higher plants. But their office in the great scheme of life is by no means unimportant.

Microbes.—Little as we know of the extremely minute organisms known as *microbes*, including *Bacteria*, *Bacilli*, and other forms, it is sufficient already to enable us to appreciate something of their enormous influence. These plants, so minute as to require the very highest powers of the microscope and the aid of colouring matters to render them visible, are, or many of them are, manufacturing chemists on a large scale. They convert some of the insoluble and in-nutritious particles of the soil into the soluble and the nutritious, and in this way they may and do provide nourishment for other plants which otherwise could not exist on such soils. How they accomplish the feat is not fully known, but, at any rate, we have now learnt to look with much more respect upon these humble organisms than our fathers (if they saw them at all) were able to do.

Symbiosis.—A third category, that of *messmates* or co-operators, has now to be added to the "parasites" and "saprophytes." It is not only minute bacteria that co-operate with the more highly organized plants for the common benefit, but some of the fungi, big enough to be easily seen by the naked eye, and which used to be looked upon as deadly enemies, are now known to exist peaceably on the roots of some of the higher plants, and even to contribute to their requirements, while themselves deriving benefit from the association. This association for purposes of mutual accommodation is called *Symbiosis*; and although it may seem outside the range of practical gardening, we mention it here, as it is by no means unlikely that the want of success with certain plants of which gardeners complain may, as suggested by M. Naudin, eventually be found to be due to the absence of some particular bacterium or fungus necessary to the welfare of the plant (fig. 25).

On the other hand, some of these bacteria are indeed ministers of decay and death. They are always associated with putrescence and corruption, and some of them, by reason of their poison-generating properties, produce disease and death in plants and animals, including human beings.

Mention is made of these things at the outset for the purpose of impressing on the student that, although it is convenient for him, or perhaps inevitable, to study one plant, or one part

of a plant, at a time, yet in nature, as a rule, no such isolation occurs. One part influences another, one plant competes with another, some are allies and confederates, others are antagonists or enemies, all are subject to varying effects of climate and soil; and thus the life-history of even the humblest plant is complex to a degree that the student who confines himself to reading about it alone cannot adequately appreciate.

Chlorophyll-producing or green plants fall into two or more series; the simplest are pure thallophytes; such are the Algæ, which have



Fig. 25.—Illustrations of Symbiosis.

1. Roots of the White Poplar with Mycelial covering. 2. Tip of a Root of the Beech with closely adherent Mycelial covering; $\times 100$ (after Frank). In these cases the Mycelial threads on the roots are of fungous origin, deriving nourishment from the roots on which they grow, but at the same time supplying food-material to the roots.

a "thallus" only. More highly organized are the Mosses, which have distinct traces of stem, leaf, and root as we recognize them in higher plants, and which also present a slight tendency to form vessels as well as cells. Higher still in degree of organization are the Ferns, in which root, stem, and leaf are even more decidedly marked, and in which the woody and vascular tissues are well marked. All these plants increase by division—one cell divides into two, those into others, and so on. In addition to this process of increase, all, or the vast majority of plants, reproduce themselves by the formation of an entirely new plant, which is the result of the union and interaction of two separate cells, the one male, the other female. In the more highly organized of the green plants the male cells, *microspores* or *pollen-grains*, are formed within cases called *anthers*, which form part of the *stamens*; while the female cell is formed within the *ovule*, a little body contained within the *ovary* or immature "fruit". These matters will require further explanation later on. At present it is sufficient to emphasize the fact that all complete plants pass through an asexual stage,

during which they may grow and even multiply by subdivision; and a sexual stage, in which they reproduce themselves by means of the conjoint action of the male and female cells.

Those chlorophyll-producing plants which have anthers containing male spores (pollen) and ovules

containing one or more female cells (oospheres) are the so-called *flowering plants*. These are vascular as well as cellular in construction, and are in all ways the most highly organized of all. It is with such plants that the gardener has most to do, and to which, therefore, most atten-



Fig. 26.—To show contraction induced by the contact of insects. Tentacles on Leaf of Sun-dew (*Drosera*).

1. Glands at the extremity of a Tentacle; $\times 30$. 2. Leaf with all its Tentacles inflexed towards the middle. 3. Leaf with half the Tentacles inflexed over a captured insect. 4. Leaf with all the Tentacles extended. Figs. 2, 3, and 4 $\times 4$.

tion will be given in these pages. Flowering plants have mostly well-marked roots, stems, buds, leaves, and flowers, to each of which a few words must be devoted.

SENSATION AND MOVEMENTS IN PLANTS.

In animals sensation is made evident by the medium of nervous tissues. Plants have no distinct nervous apparatus, but the protoplasm of which they consist is very sensitive to impressions of various characters. It has, as the chemists say, a great affinity for water, by virtue of which property it absorbs large quantities of fluid, and by the alternate turgescence and flaccidity which ensue the form is greatly altered. Furthermore, it is contractile, the contraction being influenced by light, heat, by chemical substances such as acids, electrical currents, and so on, matters that must here be dismissed with the mere mention. Nevertheless, the movements which are witnessed in leaves, tendrils, root-tips, and twining plants, in the opening and closing of flowers, the growth-movements of roots and of shoots generally, are all dependent upon impressions made by various agencies singly or in combination on the protoplasm. It is probable that some of these movements are not only dependent physically on the varying amounts of turgescence in the protoplasm, but

also on chemical changes in the constitution of the fluids; thus, in so-called insectivorous plants, such as *Drosera* (fig. 26), it is not merely the mechanical stimulus of touch which causes the leaf, or portions of it, to fold over the intruding

substance; for if the substance be of a nitrogenous character, as the body of an insect or a fragment of meat, a "ferment" is formed in the protoplasm which dissolves the meat and ensures its absorption. The movements of the leaves of sensitive plants also are not only accompanied by variations in the amount of turgescence, but also by changes in the chemical constitution of the cell-juices. These phenomena are facilitated by the passage of threads of protoplasm from one cell to another through minute

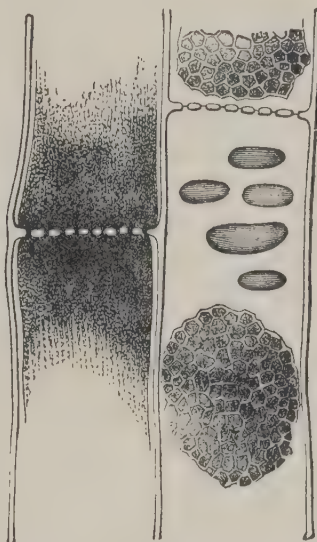


Fig. 27.—The figure shows the partition between the cells perforated by very minute apertures, through which threads of protoplasm pass from one cell to the other. To see these phenomena the tissues require to be stained and examined under a high power of the microscope.

openings in the cell-walls (fig. 27), so that there is a "continuity of protoplasm" throughout the entire plant. In the expansion and closure of the parts of the flower the movements appear

to be attributable to the combined effect of heat and light. As the temperature increases, and the light gains in intensity, the flowers open, activity or turgescence being most apparent in the dorsal or outer surface of the petals. Then, as the temperature falls and the light diminishes, the energy is most displayed on the inner surface, causing them to close over and shelter the interior of the flower from excessive nocturnal radiation.

The influence of light is further shown by the way in which the leaves and flowers move and turn so as to expose themselves to it; such movements are called "heliotropic". On the contrary, roots have a tendency to avoid the light, and in the case of ivy growing on a wall we have a marked illustration of the leaves turning towards the light, whilst the rootlets protruding from the stem grow in the opposite direction.

The "heliotropic" movement in the case of leaves of course favours the process of nutrition or assimilation, but the actual growth which results from that assimilation is favoured by darkness. A plant grows more vigorously in the dark, other conditions being equal, than in the light. Roots show a marked tendency to move and grow in the direction where water is to be found, a phenomenon which is indicated rather than explained by calling it "hydro-tropism".

[M. T. M.]

CHAPTER III.

THE RADICLE AND THE ROOT.

NATURE AND MOVEMENTS—ROOT-HAIRS—THE ROOT-CAP—
—ROOT ACTION—VARIOUS FORMS OF ROOTS.

As a general rule, subject to very few exceptions, all the higher green plants have roots, and even many of the Thallophytes are provided with cells, which are root-like in appearance and office. In the higher seed-bearing plants the root is the first member that becomes visible when the seed-shell cracks open to liberate the growing embryo or seedling plant. Almost any germinating seed will illustrate the chief features of the root; take *Penstemon* as a convenient example (fig. 28), or the gourd (fig. 34). The radicle, or primary root, as it first emerges is a mere thread tapering, or a little pointed, at the free end. That free end has an invincible tendency to turn down towards the earth. If so placed that it must perforce go upwards, it will, as soon as the resistance is overcome or evaded, turn downwards. The down-

ward direction of the root is, of course, obvious to every observer. Not so readily seen is the gyratory or twisting movement that takes place at the tip of the growing root, nevertheless it is as general a feature of the root as is its downward course.

How the roots descend, and how they gyrate, must be left to the physiologist to ascertain. It is of more concern to the gardener to know why they do so, and as to this point there is not much difficulty. They worm their way amid the particles of soil in order to extract from them their food supplies. To appreciate

this, let us glance for a moment at their structure, remembering that we are concerned at present with the root in its simplest and youngest state. It is now a delicate thread destitute of green matter, and unprovided with leaves, leaf-scales, or buds. It cannot, therefore, do the same sort of work that the leaf does. An examination with a pocket lens, which no gardener should be without, will, in



Fig. 28.—1. Seedling of *Penstemon* with the long absorptive cells of its root ("Root-hairs") with sand attached. 2. The same seedling: the sand removed by washing.

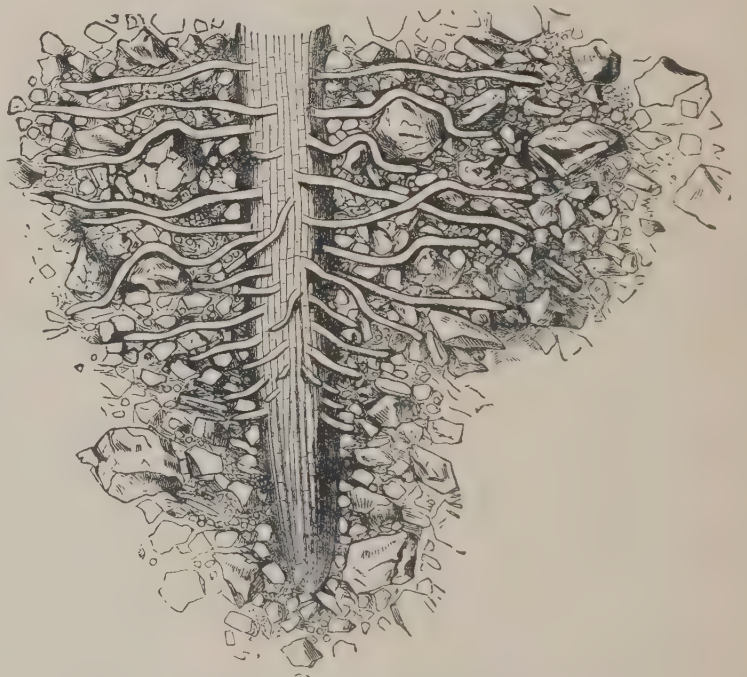


Fig. 29.—Root-tip of *Penstemon* with Root-hairs penetrating between the particles of soil; $\times 10$.

many cases, show, just above the extreme tip of the root, a fringe of the finest possible white glistening threads. These are the *root-hairs*. When food supplies or moisture is abundant, and easy to procure, then these root-hairs are proportionally numerous, and, as in the case of vine roots in a well-made border, may be seen investing the fragments of manure or bone as it were with a miniature cobweb (figs. 29, 30).

In this condition they are not unlike the minute threads of a fungus, but the hairs are shorter, straighter, and not so much interwoven.

The extreme tip of the primary root generally looks a little thickened; and if it be examined with a magnifying-glass, a little thimble-shaped

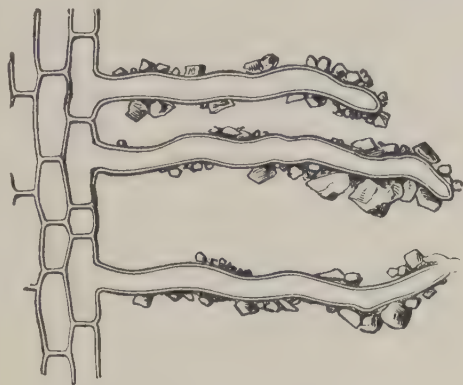


Fig. 30.—Root-hairs or Absorptive Cells of Penstemon with adherent particles of earth.

sheath may be observed covering the end of the root. This is the *root-cap* (fig. 31). It may be seen with an ordinary pocket magnifying-glass in the roots of duckweed (*Lemna*), and by the aid of the microscope in almost all roots in their young state. The root-cap acts as a protection to the young growing-point of the root. As the direction of growth of the root is from above downwards, it is obvious that the roots, by reason of the screw-like movement before mentioned, insert themselves between the particles of the soil,

and in so doing would be likely to injure the delicate young cells at the tip were it not protected by the root-cap. Already then, in this early stage of the root, we find variations

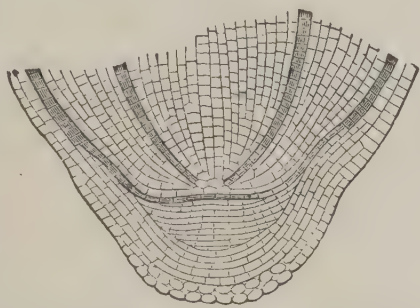


Fig. 31.—Section through the Root-tip of Penstemon. The bowl-shaped mass at the tip is the root-cap; $\times 60$.

in structure; we find root-hairs and we find a root-cap both produced from the outer portion of the root, the one alive and active, the other dead but protective. The main portion of the root is occupied externally by cells only, which constitute the *cortex* or rind, whilst the extreme centre is occupied by a strand of cells which have lost their original more or less globular form, and have lengthened into vessels and tubes of various kinds.

Root Action.—The root is now complete as to essentials, and is fully equipped for work. What is that work? Briefly, it is the absorption of water and air from the interstices between the particles of soil, and from the film which covers each particle. That water contains, in solution, some of the food which is required by the plant. We say some, because there is much that is not soluble in water, and so the plant might starve

in the midst of plenty were it not for two circumstances that enable it to avail itself of matters that are usually insoluble. One is the presence of the right kind of microbe, or bacterium, to convert the insoluble into the soluble; the other is a property with which the protoplasm of the roots themselves is more or less endowed, that of secreting a solvent juice which, coming into contact with certain elements of the soil, effects, with the addition of water, the dissolution of some of the earthy or mineral matters of the soil, and renders them available for absorption by the plant.

But it is not only liquid food, or liquids out of which food can be manufactured, that enter the plant by means of the fine extremities of the roots, and by the root-hairs in particular; gases are also absorbed, and in particular oxygen gas. This statement can only be proved in the laboratory, but the ill effects consequent on excluding the air from the roots are familiar to gardeners in the case of trees that have been planted too deeply, or whose young feeding roots are buried beneath an impermeable coating of asphalt, or even soil so trodden down or so stiff as not to allow of the penetration of the air.

So far we have been assuming the existence of a single root-fibre, as in a seedling plant of mustard, but in most cases the root does not remain in this simple condition; it branches and branches again till often a dense network of

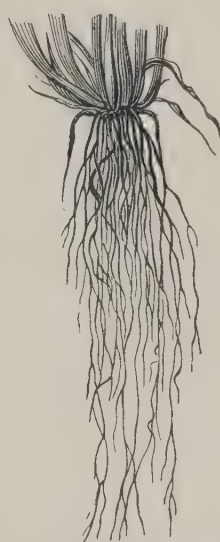


Fig. 32.—Meadow Grass—Fibrous Root.

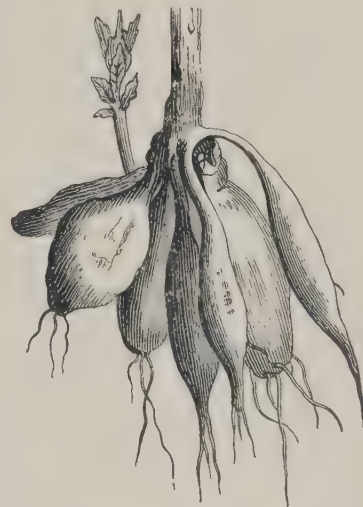


Fig. 33.—Dahlia—Tuberous Root.

so-called *fibrous roots* is formed, as in the case of grasses (fig. 32). These branches, unlike the root-hairs which spring from the surface, only emerge from the central portions of the root and make their way outwards. In other instances the original body of the root remains, increases in size and thickens in texture, so that we get what are termed *tap-roots*. Sometimes, as in the

carrot, the cortex or rind of these tap-roots increases very much in thickness, owing to rapid multiplication of the cells. In these cells a large quantity of water and food-materials is stored up, so that the plants are thereby protected against the effects of drought, whilst the food-materials are available for use when growth is going on actively. Moreover, they are serviceable as food for man or animals, and for this reason they are cultivated. Sometimes, as in the Dahlia, it is the branches of the roots which become tuberous and store up in their cellular tissue food-materials for next season's consumption (fig. 33). Should the central rather than the cortical parts of a tap-root become developed, and should they become woody rather than succulent, then the roots become woody as in trees. Such roots not only act as conduits and store places, but their size, their strength, their manifold and widely-spread branches, enable them to act as efficient anchors and to prevent uprooting by storms. The old woody parts of the roots are never clothed with root-hairs, and have nothing to do with the absorption either of liquids or of gases, those functions being exclusively confined to the root-hairs, or to the finest root-fibres.

Such, in very general terms, are the structure and office of the root. In detail there are great differences in form and internal structure, but none of them affects the general principle of root-action, nor, so far as we know at present, are the diversities of internal structure of direct practical importance to cultivators.

The young gardener, however, will do well to pay great attention to the different forms and degrees of branching in roots, for it is evident that his treatment of plants must vary considerably according to the nature of the roots. To expect a fine, delicate-rooted plant, like a Heath, for example, to thrive in dense clay is to expect the impossible. Indeed such matters as the choice and composition of soils and composts, the securing adequate drainage, the method of potting, and the many circumstances regulating the administration of water, are all directly dependent on the nature and office of the roots.

The root as above described is the seedling root or its direct continuation. The seedling root, however, very often perishes, and secondary roots are formed to supply its place. These secondary roots, which emerge from the base of the stem, or even from the leaves, have essentially the same structure as the seminal root and perform the same offices. "Adventitious roots" of this character are very common on the stems of vines, and generally indicate either

that the atmosphere of the house is too moist and stuffy, or that the true roots do not obtain sufficient moisture from the border. [M. T. M.]

CHAPTER IV.

THE CAULICLE—THE STEM.

THE PRIMARY BUD OR PLUMULE—THE STEM—THE CAMBIUM—THE WOOD—THE BAST—VARIOUS FORMS OF STEMS: BULBS, TUBERS, &c.—STRUCTURE OF STEM.

Referring again to the seedling plant of penstemon or the gourd (fig. 34), it may be noticed that the root tapers gradually downwards into the soil, whilst the two seed-leaves (*cotyledons*) are borne aloft upon a slender shaft which is perfectly cylindrical, wholly unbranched, and destitute of root-hairs. To the naked eye, then, this little shaft differs materially from the root. In internal structure it differs still more. It is, in fact, the first representative of the stem, and is known as the "caulicle", or sometimes, from its position below the two seed-leaves, as the *hypocotyl*. Its object is to upraise the two seed-leaves and enable them to be exposed to the influence of sunlight and air. Another purpose it fulfils is to convey the water absorbed by the root-fibrils and root-hairs up to the leaves. In some cases it has yet another office, that of storing up food-materials and water to supply the necessities of the growing plant. The thick portion of a radish or a beet, for example, though usually called root, is not truly so named, as it is in reality a development of the caulicle. The direction of growth, the form, the absence of root-hairs, branches, and, of course, of a root-cap, all serve to distinguish the caulicle from the radicle.

The Primary Bud.—Above the two seed-leaves we find the young growing leaves closely crowded together and forming a "bud", such bud consisting of a very short stem from the sides of which are given off the leaves. This, the first bud of a plant, is called the *plumule*. In the case of an annual plant this plumule is the only real bud that the plant makes; for the formation of a bud, as we shall see later on, implies a check or arrest of growth, which does not occur, at least not in a very definite way, in the life of an annual plant. In any case, whether the plant live through one season or through many, the "plumule", or first bud, gradually lengthens, dilates, becomes succulent or hardens into wood, remains unbranched, or, as is more usually the

case, branches more or less according to its kind. It becomes, in fact, a stem.

The *stem*, like the root, has an external skin overlying a cellular cortex, whilst in the centre is a cylindrical strand of wood-cells, tubes, and vessels of various shapes. The arrangement of these several parts differs in different plants, and undergoes great modifications according to age. The wood-lined cells and tubes serve to strengthen the plant and support it; the various vessels with thinner coats serve to convey the fluids from the root upwards, or from the leaves downwards, or

sideways, according to the requirements and local activity of the plant. Of the cells of the cortex or rind some become "corky", and the impermeable cork preserves the tissues either from the introduction of water from without or from the evaporation of too much water from within, according to circumstances. Others of the cortical cells become store-places for water, for starch, for chlorophyll, or other food-materials and products, or for various secretions. Others again stiffen into fibres, which, together with the "wood" of the central cylinder, serve to strengthen the plant and enable it to maintain its upward direction.

In addition to all these there is, during the active growing period, a series of cells called

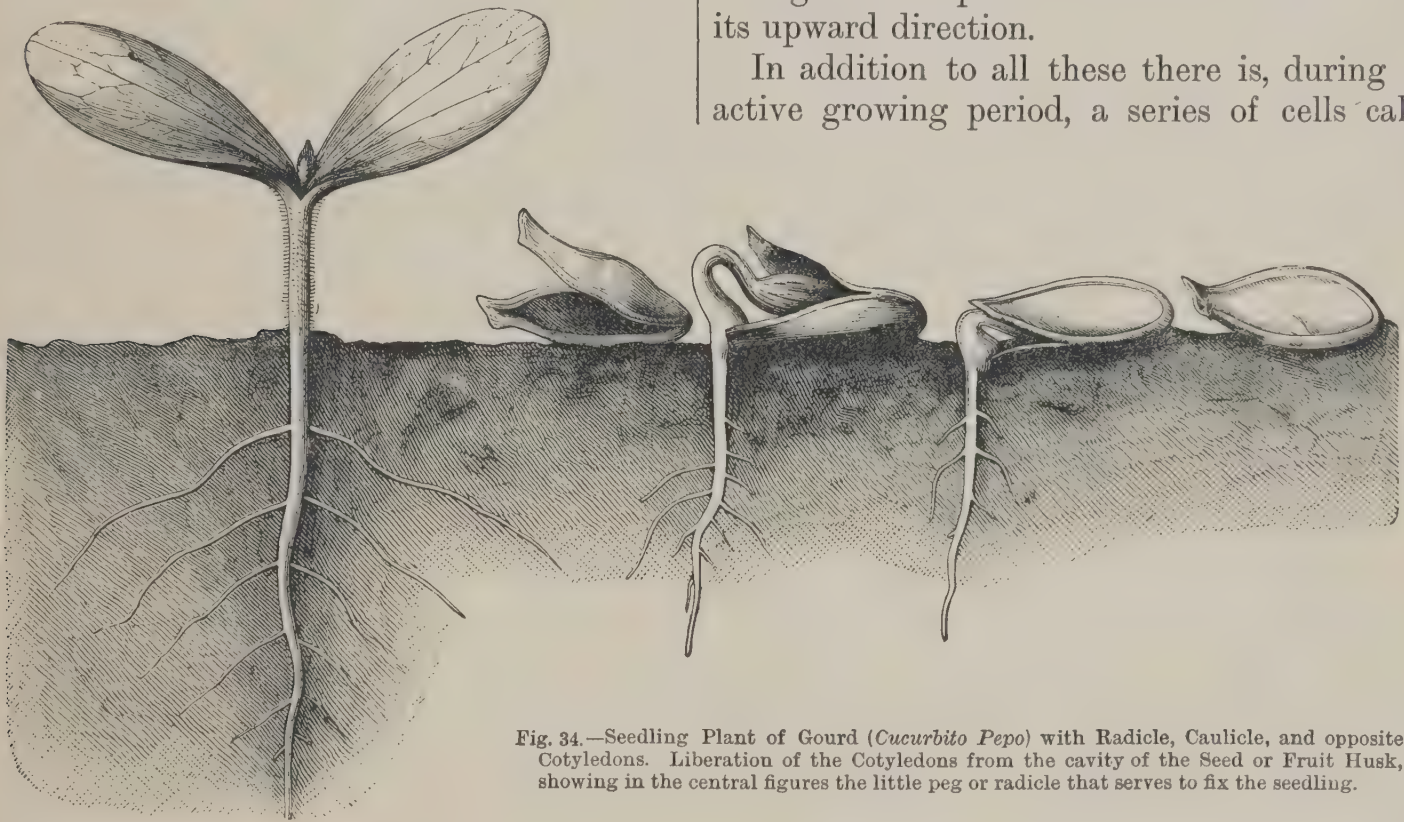


Fig. 34.—Seedling Plant of Gourd (*Cucurbito Pepo*) with Radicle, Caulicle, and opposite Cotyledons. Liberation of the Cotyledons from the cavity of the Seed or Fruit Husk, showing in the central figures the little peg or radicle that serves to fix the seedling.

collectively the *cambium*, which, in the great majority of the plants with which the gardener has to deal, lies between the layers of the cortex or bark and the layers of the wood, and in the young state between the masses of *xylem* or wood, and *phloem* or bast. The cambium cells, or *meristem cells* as they are also called, are usually relatively small, thin-walled cells, whose protoplasm is in a specially active condition, so that new cells form rapidly to add to those of the cortex on the one side, and to those of the wood-cylinder on the other.

From these general statements it will be seen that the stem and its branches, which are merely repetitions on a smaller scale of the original stem, are the direct outcome and result of the growth and development of the caulicle or of the plumule, or of both.

As a general rule the stem shows a tendency to ascend, so as to place the leaves which it bears under the most favourable circumstances, and hence the great majority of the stems are

aerial, and they vary considerably in size and form. They may be soft and herbaceous when of short duration, or hard and woody when their life extends over a longer period. Not unfrequently they climb by encircling trees and branches, as in the case of the Scarlet Runner, and thus secure to their leaves all the advantages of light and air without the expenditure of much force or material in the formation of a woody stem. But a great many stems or branches, instead of ascending, creep along the surface of the ground, or are entirely subterranean, so that they are commonly mistaken for roots. Such stems may be distinguished not only by their minute anatomy, which is that of the stem, but by the scales or rudimentary leaves which they bear, and by their "eyes" or buds. A potato, for instance, is neither a root itself, nor the direct product of a root. It is the thickened end of a subterranean branch; the "eyes" are the buds, which will eventually lengthen into shoots. Under-

ground stems go by the general name of *root-stock* or *rhizome* (fig. 35), and as special varieties of it may be mentioned the *tuber*, a more or less



Fig. 35.—Rhizome of Iris.

globular or oblong swelling of a branch, as in the Potato; the *corm* (fig. 36), a globular dilatation of the stem, with a few leaves in the shape of scales outside, as in the *Crocus* or the *Gladiolus*; or the *bulb*, where the scales are numerous and the stem relatively small (figs. 37, 38). Similar bulbs and tubers may occasionally be found on the stem in the axils of the leaves (fig. 39).

Creeping roots, so-called (fig. 40), are usually slender branches, creeping along on the surface of the ground, or just beneath it, provided with leaf-scales, or even true leaves, and giving off roots from their lower surface. A strawberry runner is a branch of this character, designed, as it would seem, to secure to the young plant at its extremity a new habitation where the soil has not been so



Fig. 36.—Colchicum—Corm.

much exhausted of its constituents as must be the case in the vicinity of the parent plant.

Stem Structure.—The general structure of an

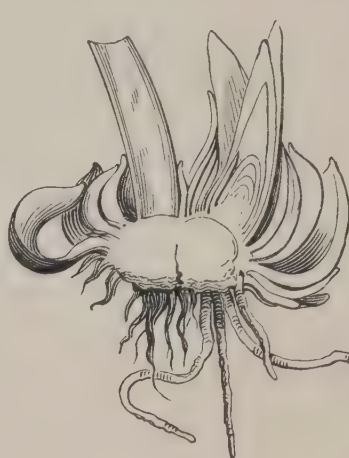


Fig. 37.—Lily—Scaly Bulb.

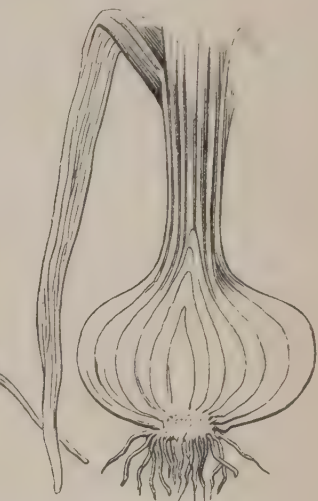


Fig. 38.—Onion—Tunicated Bulb.

herbaceous stem or shoot has been already referred to, but during its conversion into a woody branch or stem numerous changes occur. The outer skin or "epiderm", at first continuous

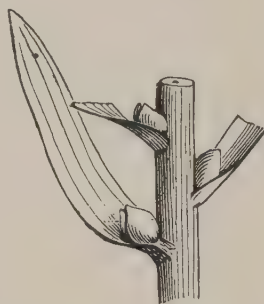


Fig. 39.—Bulb-bearing Lily—Portion of Stem.

with that of the leaf, generally disappears, the cellular cortex beneath becomes differentiated into various portions as before stated. Then comes the *cambium* or formative layer, and within that the wood, encircling a cylinder of cellular tissue called the *medulla* or pith. The

"wood", or the woody bundles, form a ring of wedge-shaped masses around the pith, the wedge-shaped masses being separated one from the other by rays of cellular tissue passing radially outward from the pith to



Fig. 40.—Carex—Rhizome.

the cambium (fig. 41). These are the *medullary rays*. The pith and the medullary rays are part of the "fundamental tissue" of which the whole stem or branch in its young state consists.

Some of the cells of this fundamental tissue remain unchanged, others become differentiated or converted into tubes and vessels of different character. The most important change, from our present point of view, is the formation of the woody bundles. These in an ordinary tree or shrub consist of cells, some unchanged or relatively so, others converted into thick-walled tubes or vessels, and these constitute the *wood* of the bundle turned towards the centre of the stem. Other of the constituent cells lengthen into tubes with delicate thin walls, and these constitute the "*bast*" on the outer side of the bundle. Between the bast and the wood are some active growing cells constituting the *primary cambium*.

When the second season's growth begins, these cambial cells develop a layer of secondary wood on the inner, and a layer of secondary bast on the outer side of the first ring, and so it comes about that the wood of most trees and shrubs presents to the eye, when cut across, a series of concentric rings traversed by radiating medullary rays. As in this country in ordinary seasons one such ring constitutes a season's growth, it follows that the number of rings offers a very close approximation to the number of years that the tree has lived. But allowance has to be made in certain cases for the fact that

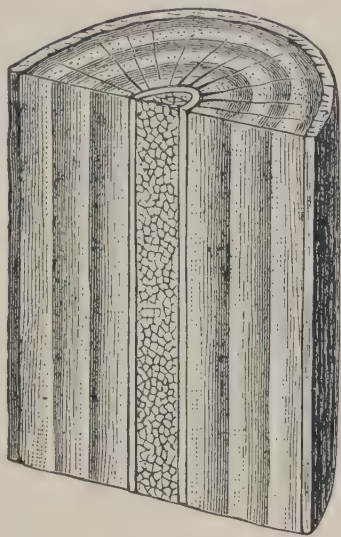


Fig. 41.—Section of Exogenous Stem, showing central pith, three zones of wood, and bark on the outside (diagrammatic).

scribed apply only to ordinary trees and shrubs, such as spring from seedling plants that produce two cotyledons or seed-leaves. The structure of the stem and of its constituent bundles varies greatly in plants the seedlings of which have but one seed-leaf, and in ferns. In palms, for instance, the vascular bundles are not arranged in rings of wedge-like masses, but are dotted irregularly through the fundamental tissue, and the constitution of the bundles is different. Still more varied is the state of things in Tree Ferns, wherein the bundles are arranged in wavy plates in the midst of the fundamental tissue (fig. 42). For full accounts of these diversities recourse must be had to the ordinary textbooks. Their relation to practical cultivation has not yet been made fully apparent.

[M. T. M.]

CHAPTER V.

THE LEAF—THE COTYLEDONS.

FORMS OF THE LEAF—SIMPLE LEAVES—COMPOUND LEAVES—LEAF-STRUCTURE—EPIDERMIS—PAIRS—LEAF-ACTION—EVAPORATION—RESPIRATION—ASSIMILATION.

The presence of a more or less flat, green plate, or of a series of such plates, is an extremely frequent characteristic of plants. We saw it in the simplest form in the "*thallus*" of sea-weeds, in some of which, moreover, it branches and assumes forms outwardly as complicated as those which are met with in the higher plants. In Mosses the stem with its projecting leaves is very prominent, whilst in the Ferns the leaf forms the most prominent part of the whole plant. The leaf is also generally very well marked in the higher seed-bearing plants, and, in alluding to the seedling plant of the penstemon, we have spoken of the two first leaves raised upon the caulicle as seed-leaves or "*cotyledons*" (fig. 28). Plants that have two such seed-leaves, as the penstemon, are spoken of as *Dicotyledonous*, others that have one are called *Monocotyledonous*, as the wheat or the lily. The presence of one or of two cotyledons, as the case may be, is associated with other differences, so that when a plant is classed as a "*Dicotyledon*" we do not mean simply that its embryo or seedling plant produces two cotyledons, but also that its wood is in rings, as previously explained, whilst there are other differences in the leaves and flowers which will be mentioned later on. The classification of all seed-bearing plants into Monocotyledons or Dicotyledons is very im-

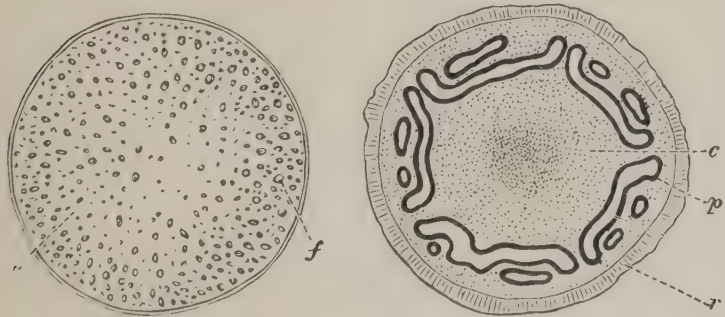


Fig. 42.—Section of Endogen and Acrogen.

a ring may be imperfectly formed in some seasons, or that a second may in other seasons be developed in the same year. The number of the rings is, however, a pretty sure approximate index of the age of the tree or branch; whilst their thickness and condition afford an indication of the climatal vicissitudes to which they were subjected in any particular year.

The structures and arrangements above de-

portant and “natural”, inasmuch as, while it expresses one point of difference, it implies many more which are associated with it, but which are not specified. The cotyledons are flat and green

and generally of simple conformation (fig. 43).

When this is the case, as in the penstemon, they do the work of leaves from the first, and the young seedling can take care of itself from the time when its seed-leaves are unfolded. In other cases the cotyledons remain under-

ground, when they are generally thickened and contain a store of ready-made food-substances upon which the young plant can feed

till it is able to supply its requirements by the agency of the leaves (fig. 44). After the cotyledons the true leaves appear from the sides of the stem and branches.

Leaf Forms.—Nothing can be more varied than the form and appearance of the leaves in different plants, and even on the same plant the difference is sometimes very great. This difference is generally associated with variations in function. If a leaf has to serve the office of protection only, it is then represented by a mere scale, a “leaf-scale”, such as is found on the outside of a bud. If its office is to act as a store for water or food-materials, then it is thickened and swollen. If it is to fulfil the complete office of a leaf, then it is broadly expanded to secure exposure to light and air, and its structure and appearance are



Fig. 43.—Seedling with opposite Cotyledons and alternate Foliage-leaves (*Cytisus Laburnum*).

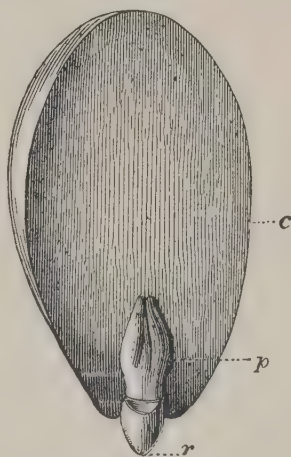


Fig. 44.—Embryo of Almond with one cotyledon removed. *c*, Fleshy cotyledon; *p*, plumule; *r*, radicle.

greatly modified according to the circumstances in which the plant is placed. A complete leaf, or, as it is sometimes called, a “foliage-leaf”, has a stalk or *petiole*, the lower part of which often broadens out into a “sheath”, whilst the upper part dilates into a flat plate called the limb or blade. When the leaf-blade emerges from the cortex of the stem or branch without

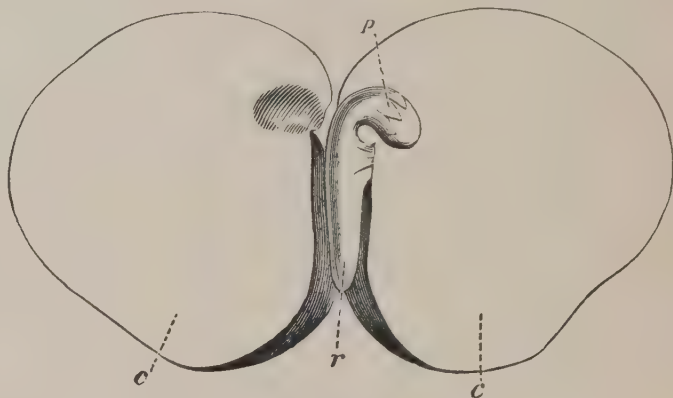


Fig. 45.—Pea—Cotyledons opened out.

Thick cotyledons acting as store-places for food for the use of the embryo-plant during its growth. *c, c*, The Cotyledons; *p*, the Plumule or Primary Bud; *r*, the Radicle.

the interposition of any stalk, the leaf is said to be *sessile*.

The points on the stem or branches whence the leaves emerge are called *nodes*; if these are close together, the leaves are in tufts or rosettes; if separated, then the space between any two leaves is called the *internode*. The manner in which successive leaves spring from the nodes of the stem is a point of much importance to be determined. If they spring in succession, the leaves occur at different heights or planes and are then said to be *alternate* (fig. 43). If two leaves originate at the same time, one on one



Fig. 46.—Oleander—Verticillate Entire Leaves.

side of the stem, one on the other, at the same level, they are called *opposite* (see fig. 34). If more than two spring from the same level, they are said to be *whorled* or *verticillate* (fig. 46). So, too, the leaves may be arranged in two, three, four, five,

or more vertical rows, and a spiral arrangement may then readily be traced.

Individual leaves are “spreading”, or “appressed” against the stem; erect, deflexed, or bent downwards. The form of the leaf is infinitely varied. Distinct terms are applied to express those differences. These are given in every ordinary text-book. In this place we can only allude to a few of the most important

variations; thus, leaves are spoken of as “entire” when the margin is continuous (fig. 49), “toothed” (as in fig. 47), “lobed” or “divided” when the leaf branches more or less deeply so as to form “lobes” or “segments”, and “compound” (figs. 48, 49) when the branching is carried to such an extent that the leaf divides

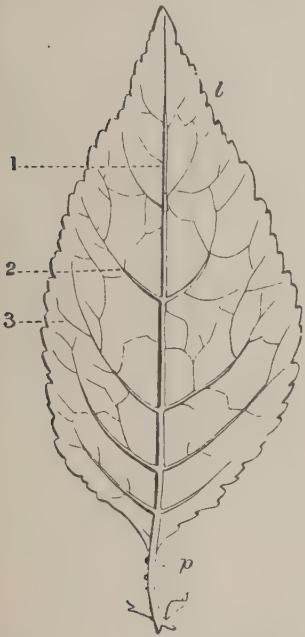


Fig. 47.—Cherry—Simple Leaf.

p, Petiole, with Stipules at the base; 1, midrib; 2, 3, branches of the midrib.

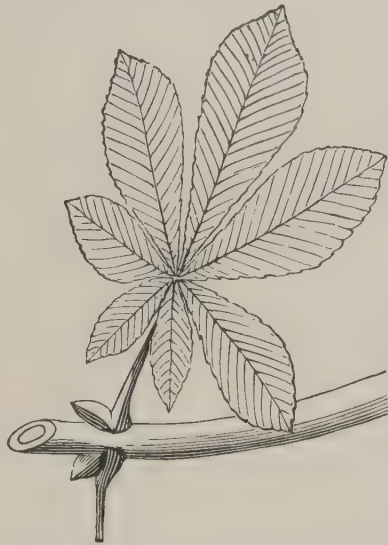


Fig. 48.—Horse-chestnut—Compound Palmate Leaf.

into numerous eventually separate pieces or leaflets attached to the central stalk by a distinct little joint. When the subdivisions or leaflets diverge or radiate from the top of the leaf-stalk, the term *palmate* (fig. 48) is employed, as in vines, fan-palms, or strawberries; when they spring at intervals from the sides of the leaf, then the word *pinnate* (fig. 49) is made use of, as in the rose-leaf. It is requisite also to pay attention to the “base” of the leaf, that portion nearest to the petiole; to the “apex”, that portion farthest from the petiole; and to the “margin”, which, as has been pointed out, is entire, or variously toothed or lobed. The “midrib”, or direct continuation of the petiole, must also be noticed, as well as its subdivisions or “veins”. In most Dicotyledonous plants there is one prominent *midrib*, from the sides of which branch off numerous *veins* arranged usually in a close, irregular network, so that Dicotyledonous

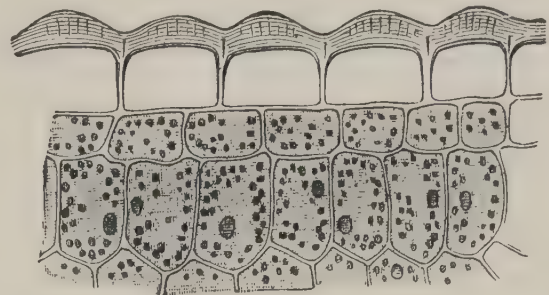


Fig. 49.—Robinia—Compound Unequally-pinnate Leaf.

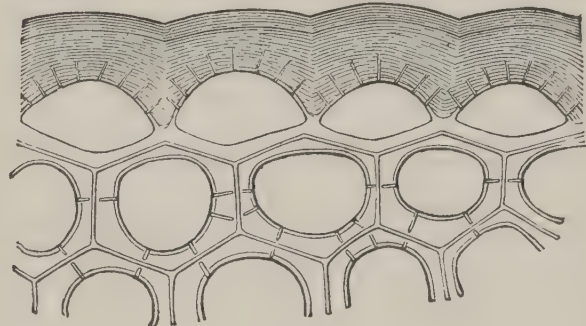
plants may often be recognized by the mere inspection of their leaves, without seeing their cotyledons, their wood, or their flowers. Net-veined leaves are, with few exceptions, characteristic of Dicotyledons, as straight-veined leaves are of Monocotyledons. It must be remembered that the terms ribs, veins, nerves, are employed in botany without any reference to their use.

The surfaces also demand attention, being *glabrous*, that is, free from hairs; *glaucous*, bluish-green; or more or less and variously *hairy*, appropriate terms being given in each case. The lower surface of the leaf is generally duller in colour than the upper.

The *internal structure*, as revealed by the microscope, has reference to the varied duties of



1.



2.

Fig. 50.—1. Shows Epiderm with thickened upper wall and palisade cells beneath, filled with chlorophyll. 2. Epidermal Cells thickened on one side, with Cellular Tissue beneath.

the leaf. Speaking generally, the leaf is made of a cellular substance which consists of an expansion of the cortex, stiffened by a framework of veins and fibres which all, or some of them, act as conduits for the transmission of fluids from one part of the plant to another. Outside all is a protective skin or *epiderm*. The epiderm usually consists of a single layer of flattened cells destitute of chlorophyll, but often thickened on one side for protection sake (fig. 50), and is covered with “cuticle”, with a waxy coating, or with thickly-felted hairs of various shapes, all provisions against excessive evaporation of watery vapour or injurious radiation of heat (fig. 51). The epiderm on the lower surface is usually thinner and is generally perforated by a number of small openings called *stomates* (fig. 52). These are bounded by two or more cells of different shape from the rest,

and which are called "guard-cells". The guard-cells become turgid or flaccid according to the cellular substance of the leaf, consisting of various layers of cells (figs. 53, 54), sometimes all alike, but more generally differing in form, colour, and function. Thus the cells immediately beneath the epiderm on the upper side are closely packed and lengthened vertically, or at right angles to the surface, so that they resemble palings, and hence they are spoken of as *palisade* cells (fig. 54). They are generally full of chlorophyll, and, being exposed to the light, are the seat of great constructive activity. Beneath the green palisade cells there are usually several layers of more or less spherical cells with little or no chlorophyll, and so loosely packed that interspaces are often left

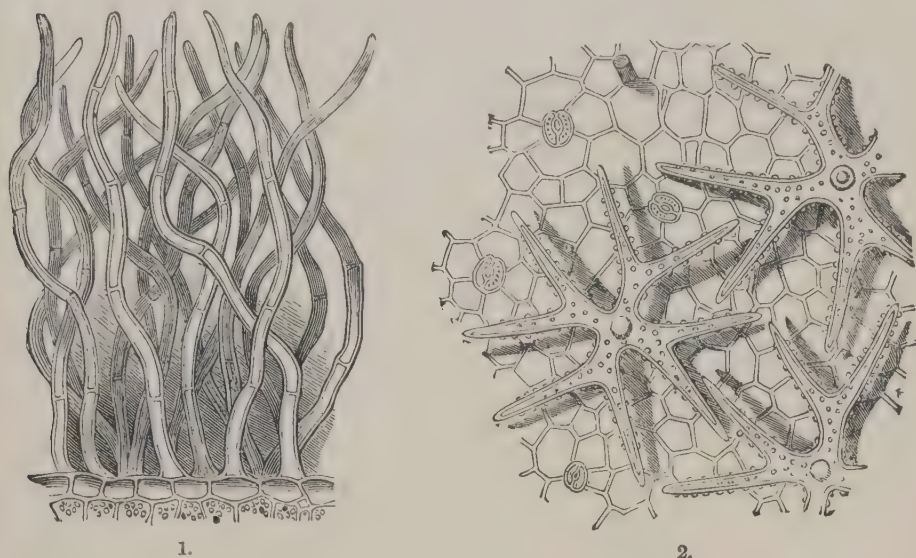


Fig. 51.—1. Felted Hairs on the surface of a plant. 2. Stellate Hairs on the Epiderm of *Deutzia*.

amount of moisture in the leaf or in the air, and thus open or close the openings according to circumstances. The stomata are usually most

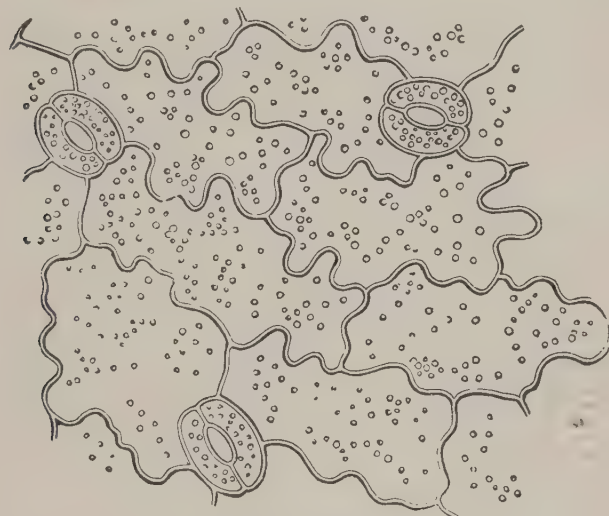


Fig. 52.—Stomata.

Surface view of a portion of the Frond of a fern, *Nephrodium Filix-mas*.

abundant on the lower surface of the leaf, but sometimes they are equally numerous on either surface, in which case the colour of the two sur-

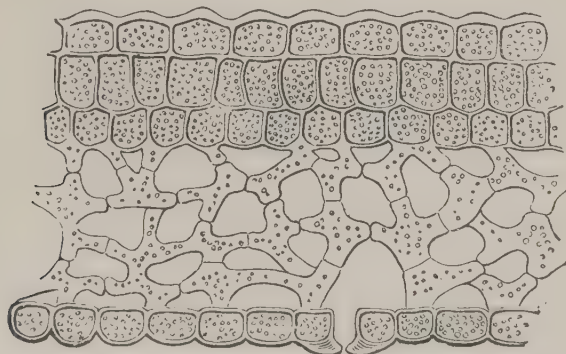


Fig. 53.—Vertical section through a Leaf, showing Epidermis, Palisade, Spongy Tissue, and a Stoma cut through.

faces is alike. Stomata are not confined to the leaf, but occur in all or any of the green parts of plants. Within the skin or epiderm is the

cellular substance of the leaf, consisting of various layers of cells (figs. 53, 54), sometimes all alike, but more generally differing in form, colour, and function. Thus the cells immediately beneath the epiderm on the upper side are closely packed and lengthened vertically, or at right angles to the surface, so that they resemble palings, and hence they are spoken of as *palisade* cells (fig. 54). They are generally full of chlorophyll, and, being exposed to the light, are the seat of great constructive activity. Beneath the green palisade cells there are usually several layers of more or less spherical cells with little or no chlorophyll, and so loosely packed that interspaces are often left between them (figs. 53, 54). These cells are not so immediately dependent on sunlight, but serve as magazines to store up water, to contain what is formed in the palisade cells, or to act as reservoirs for various secretions.

The midrib is a reduced copy, so far as structure goes, of the stem, and the "veins" have the

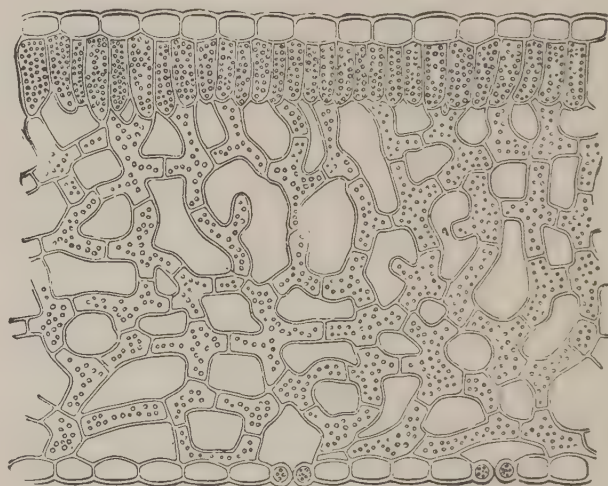


Fig. 54.—Vertical section through Leaf of *Franciscea eximia*, showing Epidermal, Palisade, and Spongy Tissue, and a Stoma cut through.

same essential structure as the midrib from which they spring.

USES OF THE LEAVES.—Whatever the position and form of the perfect leaf, its functions are the same—to inspire and expire, to absorb and to evaporate, according to circumstances, to fabricate nutrient matters under the influence of sunlight and heat. A leaf, in fact, performs duties which in an animal are carried on in separate organs, as the skin, the lungs, the digestive and the secreting organs. No wonder, then, that gardeners attach so much importance to healthy foliage. The watery fluid absorbed by means of the root-hairs passes up the stem, and at length reaches the leaves. Here such

portions or amounts as may be required are utilized or deposited, whilst what is not wanted is evaporated in the form of vapour through the stomata, or, in some cases, in a liquid state through certain openings called "water-pores".

Evaporation, then, is one function of the leaf, and we have seen how its amount is regulated by the structure of the plant itself, and by the conditions of temperature and moisture under which it is placed, how the structure of the plant is adapted to promote or to check evaporation as the case may be. The great diversity in the surface of the plant, the nature and number of its hairs, &c., have reference to the regulation of the passage in or out of gases or liquids.

Respiration or breathing is another most important function carried on in the leaves and in all the parts of plants. This interchange of gases goes on in the protoplasm of every living cell. As, however, the arrangements favouring respiration are most conspicuous in the case of leaves, it is convenient to speak of them in this place.

The process of respiration consists mainly in the absorption of atmospheric air, and in the exhalation of carbon dioxide gas. It is a process which, like the respiration of animals, is going on continually in darkness as under exposure to light; heightened and accelerated by some conditions, it is diminished or retarded by others. In animals the process is regular and rhythmical, but no such periodicity is observable in plants. The chemical results of this interchange of gases are of great importance to the plant, and should be carefully studied in treatises dealing with the chemistry of vegetation.

Assimilation, or the production and utilization of nutrient materials, is a function of the leaf that is only carried on in daylight. Chlorophyll, or green matter, is formed within the protoplasm under the agency of light, and in the chlorophyll liquid sugar and solid starch are formed in direct consequence of exposure to the light, an exposure always attended with an exhalation, not only of watery vapour, but of oxygen gas also.

Here again the chemical processes involved are numerous and complex, and the results equally so. The infinite variety in form and position of the leaf have reference, as has been said, to the protection of the leaf from injurious agencies of all kinds, and to the promotion of the proper work of the leaf. A detailed knowledge of these forms and processes must be left to chemists and physiologists; it is enough for the young gardener to know that the leaves are

among the most essential parts of a plant, that their principal offices are as just explained, and that it is his duty to place the plant under such conditions as may be most favourable to their action. Thus, he will have to apportion the amount of air and water supplied, to regulate the temperature of his houses, and the intensity of the light, and to adjust the quantity of the one to the amount and intensity of the others according to circumstances, according to the structure of the plant, and according to the object he has in view.

It is obvious that practice and experience are indispensable in such a case, but the experience may be gained more quickly, and utilized more completely, if the gardener has an adequate general knowledge of the principles upon which his art is based.

[M. T. M.]

CHAPTER VI.

NUTRITION.

CONDITIONS OF PLANT LIFE—THE SOIL AS A SOURCE OF FOOD AND AIR—THE AIR AS A SOURCE OF FOOD—THE ACTION OF LIGHT—CHLOROPHYLL—THE MOVEMENTS OF LIQUIDS IN PLANTS—THE SAP.

In the preceding paragraphs attention has been drawn to those parts most particularly concerned in the nutrition of the plant. Their structure and functions have also been indicated, so that we are now in a position to deal with the nutrition of plants as a whole. In the first place, it is obvious that the food of plants, or those things which are capable of being converted into food, are to be sought in the soil and in the air. A certain degree of heat, neither too little nor too great, but varying within wide limits according to the nature of the plant, its particular requirements at different periods, and the locality in which it grows, is also essential. The soil in winter and spring is always warmer than the air, hence the importance of "bottom heat" in plant culture. Light is indispensable in some, but not in all cases. Those plants that can live upon others as parasites, or upon ready-made food supplied by decaying vegetable or animal substances, do not themselves need to be exposed to the light. Of such nature are mushrooms.

THE SOIL AS A SOURCE OF FOOD, WATER, AND AIR.

The soil is composed of mineral or inorganic ingredients derived from the weathering and

wearing down of the subjacent rock, and of organic matters derived from the decay of once-living matters as described in the section relating to that subject. For our present purpose it is necessary to emphasize the fact that it is chiefly, though not entirely, as a source of water that the soil is important. By far the largest ingredient in the composition of a plant is water. Some plants, and some parts of plants, contain much, others relatively little, water; but in every case it is in large proportion to the other ingredients, and in every case it is derived mainly, but not exclusively, from the soil. No solid substance, as a rule, can enter the uninjured root-fibrils or root-hairs. The water soaks through the cell-wall of the fibril or hair, and thus gains access to the interior of the cell and its contained protoplasm. The water is thin, and readily permeates the membrane; the protoplasm and cell-contents are thick, hence a current is set up in virtue of which the thin water from the soil soaks through the cell-wall to mix with and dilute the cell-contents. The water in the soil consists of hydrogen and oxygen gases in combination, in the proportions expressed by the formula H_2O , the admixture of these gases resulting in a liquid, water.

The solid ingredients of the soil consist of silica, alumina, oxides of iron, lime, magnesia, potash or soda, ammonia, in combination usually with various acids, as phosphoric acid, nitric acid, carbonic acid, &c. Some of these ingredients, being insoluble in water, are of importance to the plant solely on mechanical grounds; they make the soil light and permeable, or heavy and impermeable to air and water, according as the sand (silica) or the clay (alumina) predominates. The draining, digging, trenching, harrowing, raking, hoeing, &c., practised by cultivators, have for their object the formation of a good tilth, or the preparation of the natural soil in such a way as to render its contents most freely available to the roots, and to allow of the free passage of air and water. Similarly, the formation of composts for potting purposes, such as admixtures of sand, loam, and peat, are planned with a view to meet the requirements of roots of different characters.

But some of the soil ingredients are important on other than merely mechanical grounds; they assist in the feeding of the plant. The nature of the soil-food is ascertained by the aid of the chemist, who, by analysis of the soil, tells us what it contains, and by analysis, especially of the "ash" left after burning the

plant, shows us what mineral or incombustible elements are found in the ash of the dead plant. It has been before pointed out that the mineral matters of plants are obtained exclusively through the agency of the roots, and in a liquid condition. Hence one important property of the water in the soil is to dissolve certain of the mineral or ash ingredients, and thus to render them available for the nutrition of the plant.

The analyses of the soil and of the plant made by the chemists only show us what elementary substances exist in the soil and in the plant respectively; they represent, as it were, the constitution of the "dead" soil and of the dead plant. But the soil is by no means the inert substance it was once considered to be. It is scarcely an abuse of language to say that it is alive; at any rate, under certain circumstances, living organisms abound in it and great chemical activity prevails in it. Moreover, the iron and the potash and the acids do not occur as such, but in combination, so that in estimating the amount and quality of plant-food in a soil, it is more important for us to know how much nitrate of ammonia, or sulphate of potash, or phosphate of lime the soil contains, or the plant requires, than it is to know the percentage in the soil of the uncombined elements.

The Rothamsted experiments, carried out by Sir John Lawes and Sir Henry Gilbert for more than half a century, are invaluable from this point of view. Plants of varying character and different requirements are grown under as nearly equal conditions as possible year after year, on the same land, either without manure, or with the addition of varying proportions of different substances, potash, ammonia, phosphates, &c., alone or in combination. Soil and plants under these varied conditions are analysed periodically, the drainage water from the experimental plots is collected and analysed in like manner, and the amount of rainfall, and the aggregate amount of heat throughout the year, ascertained. In this manner, independently of the chemical analyses, the several crops tell their own tale; their vigour and productiveness are indications that certain ingredients in certain proportions are necessary for the full development of some plants, different ingredients, or different proportionate quantities, being required for others.

From these and similar experiments it has been ascertained that the most important soil-foods are combinations containing nitrogen, potash, phosphoric acid, lime, and iron. These are so greatly predominant in their influence

that, for practical purposes, the other ingredients may be almost disregarded. Solutions in water of the mineral ingredients, potash, lime, iron, are absorbed by the roots. Certain substances which are not soluble in water are, nevertheless, dissolved by acid fluids exuded from the roots themselves, and the solution so formed, diluted with water from the soil, is absorbed by the root. The root in this case not only absorbs the solutions it finds in the soil, but actually dissolves the substances in the soil, and is thus enabled to utilize what otherwise would remain insoluble and inert.

Still more important to the plant than the mineral matters are the soluble *organic* matters in the soil, and which are yielded by the decay and disintegration in the soil of vegetable and animal substances, such as farmyard manure, for instance.

These substances yield nitrogen, on the whole the most important substance the plant contains, and one absolutely essential to the life and activity of the protoplasm. Nitrogen exists in the soil in the form of combinations of ammonia and of nitric and nitrous acids in association with potash and other bases. Although nitrogen forms by far the largest proportion of atmospheric air it appears that plants do not, as a rule, obtain their supplies from this source, but they get it from the soil as above explained. Moreover, it is now ascertained that in some cases certain "Bacteria" or "microbes" in the soil play a large and most important part in the nutrition of the plant, by the power they have of converting the insoluble nitrogenous combinations in the soil into soluble ones available for plant-foods. It had long been observed that nitrogenous manures, though very beneficial to cereal crops, were not proportionately serviceable to leguminous plants (peas, beans, clover, &c.), so that the application of such manures to leguminous plants is in a large measure unnecessary and wasteful. It had also long been remarked that the roots of leguminous plants always bore little knobs or excrescences such as are only met with rarely in other plants. Further investigations by microscopists have shown that the knobs are caused by the irritation set up by Bacteria or some similar organisms in the tissues of the root. Chemists have shown that these Bacteria (or some of them, for they are manifold and diverse in their action) have the property of secreting and discharging a ferment, and this ferment has the power of rendering soluble, and therefore useful, what was before insoluble and inert.

The leguminous plants, therefore, owing to their co-operation or *symbiosis* with the Bacteria, do not require nitrogen from without, but can utilize, as other plants cannot, the sources of supply furnished by the Bacteria.

Briefly, it may be repeated that root-action consists in the absorption of water containing in solution various ingredients. The absorption takes place above the root-caps at the lower end of the root-fibrils, and especially through the root-hairs when present. The substances in solution are mineral or inorganic, the most important being potash and phosphate of lime, and organic or nitrogenous supplied from decomposing organic matter in the soil, the absorption of nitrogen being in some cases brought about by the agency of Bacteria. Iron is essential to the formation of the chlorophyll of plants, as it also is to the production of healthy blood in animals.

THE ATMOSPHERE AS A SOURCE OF FOOD.

Plants can no more live without air than animals can. In both cases air is essential to the life of the protoplasm. The air contributes directly to the life of plants, and indirectly as the medium through which the sun's light penetrates. These facts, which demand no confirmation, necessarily lead to the inquiry as to what the air is and what it is made of. We cannot see it, we can judge of it by its effects, and by what happens when we are deprived of it; but the chemist can analyse it, and he tells us that, roughly speaking, atmospheric air consists of one-fifth of oxygen gas and four-fifths of nitrogen gas, together with minute quantities of carbonic acid gas (carbon dioxide), watery vapour, and ammonia.

The air so constituted enters at any part of the plant that is permeable. The entrance of air is not confined to the leaf or the green parts, but takes place over the whole available surface. The roots and the seeds breathe as well as the leaves—indeed, one of the functions of protoplasm is to breathe, to inhale atmospheric air, and to exhale carbon dioxide. In this way the plant is provided with the greater part of the oxygen and of the carbon of which it is composed. Breathing goes on night and day in the green and in the colourless parts.

But this respiratory process is, as has been already stated, not the only interchange of gases that takes place. Where green matter or chlorophyll exists, and where it is subjected to the influence of sunlight or of the electric light,

the oxygen gas is emitted, as is readily proved by simple experiments. The bubbles of gas, which appear on the surface of leaves immersed in a tumbler of water and exposed to the light, consist of almost pure oxygen gas. The oxygen, then, which is absorbed in the constant respiratory process is partly utilized and partly eliminated in the presence of chlorophyll under the influence of light. The carbon is retained in the plant and forms proportionately the greater part of its solid structure. As a consequence of this action liquid sugar and solid starch are formed in the chlorophyll, and these, together with nitrogenous compounds called *proteids*, constitute the real food of the plant. The elements that have been mentioned are the ingredients out of which, by the chemical work effected in the protoplasm, the true food is formed. The liquid food, sugar, or nitrogenous compounds, are conveyed from place to place according as they are required, the solid starch is liquefied by the action of a ferment called *diastase*, and when thus rendered capable of transport it is carried from part to part, and in many cases becomes again insoluble, and is deposited in certain store-cells, as, for instance, in the tuber of a potato. Here the starch is formed in the leaves under the influence of light and heat, and conveyed in a liquid form through the petiole down the stem into the tubers, where it is again solidified and stored for future use. Similarly the nitrogenous compounds are rendered soluble by various ferments secreted in the protoplasm, and which convert them into "peptones", which are then available as plant-foods. But these are matters for the chemist rather than the gardener to investigate.

It may be asked what becomes of the nitrogen which forms so large a share of atmospheric air? It might naturally be supposed that the nitrogenous compounds found in the living protoplasm under all circumstances were derived from the nitrogen of the atmosphere. It is, however, a well-established fact that the air supplies directly none of the nitrogen required by the plant, and that the whole is obtained from the soil and enters the plant by the roots, as previously mentioned. Although the leaves and other exposed parts of plants are, as it were, bathed in atmospheric air, it appears that they select the oxygen and the carbonic acid gas of the air and leave the nitrogen. Where and how the decomposition takes place, whether on the surface or within the plant, is not certainly determined.

As the chief chlorophyll-containing parts of plants the leaves have the greater part of the

work of the assimilation of carbon to do. They also take a share in the respiratory process. In addition to these functions they are endowed with a power—only exceptionally exerted, it would seem—of absorbing moisture from the atmosphere, and with the faculty of exhaling watery vapour, or even liquid water, through the stomata or water-pores. This latter power is constantly exercised when the temperature is sufficiently high, and when it is carried to excess the plants commence to wilt. To preserve the healthy condition of the plant there must be co-operation between root and leaf, and a proper relative proportion between the quantity of water absorbed by the roots and the quantity exhaled by the leaves. The structure and conformation of the leaves are often profoundly modified, so as to secure the plant from excessive evaporation. This is effected by an increased thickness of the epidermis, as in Cacti, by diminution of the leaf surface exposed to the light and heat of the arid deserts, by hairy coatings, by the storage and accumulation of water in the tissues, and by divers other means which offer most interesting and valuable objects of study.

In the process of evaporation the stomates, as has been previously stated, play a large part: thus, when the atmosphere is very dry, the "guard-cells" on either side of the stoma are flaccid and in contact so as to close the aperture and prevent the egress of water; but if the air be moist, and the plant well provided with water, then the guard-cells are distended and the gap between them is widened to permit the passage of the superfluous water.

THE MOVEMENT OF LIQUIDS IN PLANTS.

It has been shown that root-action and leaf-action are closely associated, and that a due proportion must be observed between the one and the other during the active periods of the plant's life. It is therefore obvious that there must be a direct connection between the root and the leaves, and that this connection must be effected by the stem. The varying anatomical structure of the several parts has been alluded to, and their use now becomes apparent. Some of the parts are adapted for the conveyance of water or other fluids, some for strengthening or for protective purposes, some for storage. The water which rises from the roots passes upwards in spring, under the influence of increasing heat, with great force and rapidity, as may be witnessed when a vine "bleeds". It passes

upwards especially through the young woody tissue, thus mounting in opposition to the force of gravity. As soon as the leaves expand the superfluous water is removed by transpiration, and thus the upward current, with its fresh supplies of mineral matter, is promoted. The cause of the ascent previous to the unfolding of the leaves is still imperfectly known. Arrived in the leaves, and exposed to the light, the water, together with the mineral matters in solution, take part in the complex chemical processes that go on in the leaf, the superfluous water, as before stated, being exhaled.

The substances formed in the leaf pass into the branches, reach the buds or other parts where growth is going on most actively, *e.g.* in the cambium tissues, or, if not wanted for immediate use, are stored up in the bark or in tubers and other receptacles. The *phloem* or *bast* tissues and those of the inner bark are those most actively concerned in the passage of these nutrient fluids. Hence, if a tree be ringed, that is, deprived of its bark so that the wood is exposed, the communications will be interrupted and the tree will die; but if the arrangement of its phloem elements be such that they are dispersed in the old wood, then the girdling or ringing is not injurious, as communications can still be maintained. Palm-trees and other monocotyledonous plants are not so much injured as others by the constriction of climbing plants, for the same reason.

The Sap.—The word “sap” was at one time in general use by botanists, as it still is by gardeners, and a distinction was further drawn between the ascending and the descending sap. But as the words in question lead to the false inferences that there is a fluid of uniform constitution ascending in a regular current, and a similar fluid of equally definite nature descending in a similarly regular channel, it is as well to abandon the use of such misleading expressions. There is no true circulation in plants, in the sense that there is in animals or in a hot-water apparatus, although there is in spring undoubtedly a marked upward current. There is no one fluid (like the blood of an animal) of uniform composition throughout the plant, the juices at one part being of a different constitution from those elsewhere, and varying also according to season and age.

There is also a passage of fluids in a downward direction, but not definitely or exclusively so throughout the plant. The juices, in fact, are transferred from point to point according to different requirements, irrespective of direction.

The passage of fluids in different directions is facilitated by the movements caused by the wind. Plants are rooted in the soil, and have not the opportunity of taking exercise that animals endowed with the power of locomotion have, but this is partly compensated for by the swaying to and fro of the young shoots.

A certain amount of heat is necessary to excite the flow of the juices, as before mentioned, and this is not confined to the root, for the shoots of a vine, for instance, may begin to grow and to push forth leaves under glass when the roots are in an outside border. [M. T. M.]

CHAPTER VII.

GROWTH AND BRANCHING.

NECESSARY CONDITIONS — DEFINITE AND INDEFINITE GROWTH—BUDS—SYMPODES—CUTTINGS—GRAFTING AND BUDDING—THE INFLORESCENCE AND BRACTS.

As a consequence of the co-operation of favourable conditions of temperature, moisture, and light in soil and air, and as a result of the processes before described, growth ensues. This growth may be a mere extension or increase of the protoplasm and cell-walls, or it may be the result of the rapid formation of new cells by subdivision of the old ones. In either way the plant may extend itself, when not obstructed, in any direction. If the force of growth be equal in every direction, a spherical form results; if growth be chiefly in the horizontal plane, a flat plate or thallus is produced. If growth in length predominate over growth in breadth, then we get long thread-like forms. When growth is more active at the circumference than in the centre, a hollow tubular or cup-like form is assumed. If growth be more energetic on the upper of two surfaces, then the upper surface is convex, $\frown$; or, on the contrary, if the growth-force is greater beneath, then the lower surface is convex, $\smile$. Of course the intensity and direction of growth vary according to times and circumstances, and thus are produced the various curvatures that we meet with in plants.

When the structure is uniform, the two surfaces are alike; but when there is a difference, the organ is said to be *dorsi-ventral*, the dorsal surface being that which is directed away from the apex or growing point, the ventral surface being that which is directed towards the centre. The dorsal surface is generally also the lower or the outer surface, while the ventral is the upper or inner face.

Generally speaking, the plant as it grows commences to subdivide by the formation and development of "growing-points", aggregations of cells which divide very rapidly and eventually break up the original unbranched body into numerous subdivisions or branches. Such growing-points, of course, occur at the tips of the roots and the ends of stem and branches, and are sometimes developed from the sides. In all cases their structure is similar, and at an early stage of their existence it is easy to recognize, by the position and direction of the constituent cells, three portions: an outer, protective, which becomes the epiderm; an intermediate, mainly constructive, which becomes the cortex; and an inner, mostly or chiefly conductive, which becomes the central cylinder of fibro-vascular tissue.

If the force of growth be about equal in the subdivisions, and the latter are about equal in size, then we have forked branching, as in the veins of ferns; or we may have pinnate or palmate modes of branching, as already mentioned in the case of leaves.

The variations in form according to the greater comparative energy of growth at particular places have already been mentioned, but it is further necessary to allude to two principal modifications which are of great importance to gardeners, viz. the *indefinite* or "*centripetal*", which is contrasted with the *definite* or "*centrifugal*" mode of growth. In the indefinite mode growth goes on either from below upwards, or from without inwards, so that the topmost or the innermost portions are the youngest. In the definite modification, the topmost or the outermost parts are the oldest. It will be seen what an important thing this is in relation to pruning and training, and it will necessarily be alluded to again in considering the inflorescence.

BUDS.

Growth may be, but very rarely is, continuous. Most commonly, especially in the higher plants, with which we have particularly to deal, growth is arrested after a time, owing to a diminution in the temperature or moisture, and is resumed when conditions once more become favourable. Thus it is that "winter buds" are formed. These are growing-points at the ends of the shoots (terminal), or at the sides (lateral). When lateral, or "axillary", they spring from the side of the stem just above the place from whence the leaf springs, from the "axil" of the leaf as it is said. The growing-points are

invested by numerous overlapping bud-scales, which are merely imperfectly-developed leaves, destined for the purpose of protecting the young growing-point and its nascent leaves from the effects of cold or excessive evaporation. The leaf-like character of these scales will be obvious to any one who will examine the unfolding buds of the Horse-chestnut or Maple. These buds may be purely leaf-buds, when they will eventually lengthen into shoots, and these will harden into branches; or they may be purely flower-buds, when they contain rudimentary flowers only; or they may be mixed buds, partly leaf-containing, partly flower-bearing. In either case the arrangement is essentially the same.

One point of great importance to gardeners is the development of the flower-buds on "last year's wood", or on "*spurs*" or short branches, as in the apple or red currant. In this case the flower-buds were formed in the autumn previous to their expansion, and may be detected all through the winter. In other cases, as in the vine, the rose, or the black currant, the buds are formed on the young herbaceous shoots formed in the same season as that in which the flowers expand. The method of pruning, of course, must be modified accordingly. Though so important culturally, this difference, great as it appears to be, is less important to the systematic botanist, seeing that different species of the same genus, e.g. red and black currants, or of Clematis, though so very closely allied, yet differ in this particular.

Sympodes.—Sometimes, when two growing-points are formed, instead of the resultant branches growing equally one grows faster and stronger than the other, or one shoot will in course of growth supplant its neighbour and take its place. Thus, in the vine it will be noticed that the tendrils and the fruit-bunches are opposite to the leaf. Originally, as may readily be seen in the young shoot, the tendril or the flower-bunch is "terminal", that is, placed at the end of the shoot, but, as growth goes on, the tendril or the bunch turns to one side, whilst growth in the direct line is carried on by the new shoot formed in the axil of the nearest leaf. Such a mode of branching, where one shoot usurps the place of another, is called "*sympodial*", the main shoot here being made up as it were of several generations or "*podia*" placed one over the other, in contradistinction to the "*monopodial*" growth, where the main shoot is unbroken and continuous.

Detached Buds; Cuttings.—Sometimes the buds detach themselves naturally from the plant, or

they form on the surfaces of leaves which fall to the ground. Such detached buds, under favour-

bud or *scion* and the *stock*. No penetration or mingling of tissues take place, but there is a passage of fluid from stock to scion, and from scion to stock. Possibly there may be a passage of protoplasmic threads from one to the other, but this has not been demonstrated.



Fig. 55.—Formation of Buds on Fronds and Foliage-leaves.

1, 2, on the pinnules of *Asplenium bulbiferum*; 3, on the margins of the lobes of the leaves of *Bryophyllum calicinum*.

able circumstances of heat and moisture, throw out roots, absorb moisture, and grow just as a seedling plant would do (fig. 55).

Gardeners avail themselves of this power of independent growth in the striking of cuttings, or in the raising of new plants from leaves pegged down to the surface, as in Gloxinias. The conditions favourable to the striking of cuttings are essentially the same as those which are propitious to the germination of the seedling plants.

When a cutting is taken a layer of impervious cork-cells is formed over the wound, then a *callus* is formed consisting of *cambium* or *meristem* cells which grow actively, the cells in the neighbourhood become filled with starch and food-materials to supply the needs of the growing tissues, roots are formed, and thus the cutting "strikes".

Grafting and Budding.—In these operations the gardener removes either a single bud or a shoot from one plant and inserts them into another. If the operation be successfully carried out adhesion takes place between the implanted

indefinite, because its flowers may go on expanding in the same order so long as growth goes on at all (fig. 56).

When, however, the topmost or the central flower of a cluster expands first, and the others



Fig. 56.—Racemose Inflorescence—Indefinite.



Fig. 57.—Cymose Inflorescence—Definite, the central flower opening first.

in succession from above downwards, then the term *definite* inflorescence is used (fig. 57). The

same mode of growth is observable when the inflorescence is broad rather than long; only, in that case, the outermost flower corresponds to the lowermost in the long inflorescence and opens first, being followed by the others in succession from the margin to the centre. In the definite mode of broad-topped inflorescence, on the other hand, the central flower opens first and the others follow in succession from the centre towards the circumference (fig. 57).

Subordinate in importance to these main subdivisions of definite and indefinite inflorescences are various methods of arrangement, of which we can only mention a few: of the indefinite forms there is the *spike*, where the flowers are sessile on a long axis, as in the Arum; the *raceme*, where each flower is attached to the main axis by a little stalk or pedicel, as in the currant; the *panicle*, where branching is carried one degree further, and the little flower-stalk, instead of at once producing a flower, branches, and it is on that branchlet that the flower is formed. Among the broad, flat-topped inflorescences we have the *head* or *capitulum*, where the flowers are "sessile", as in the Sunflower and other Composites; the *simple umbel*, or truss in garden language, as in the Rhododendron, where they are stalked; the *compound umbel*, where the stalks branch before bearing flowers, as in the Carrot, and indeed as is characteristic of the "Umbelliferae", to which order the plant named belongs.

Of definite inflorescences, where the topmost, or the central flower, according to the shape, opens first, the principal variety is the *cyme*, which may be much branched; but in any case it is the central flower of each little tuft which opens first, or, if it be a long inflorescence, the topmost one. Other variations are described in botanical text-books, to which we must refer for further details.

One other point may be mentioned, viz. that the leaves on the inflorescence, that is to say those leaves nearest to the flower, are termed *bracts*. Sometimes they are like ordinary leaves, at other times they are brightly coloured. Sometimes, as in the Arum, one large bract envelops the whole inflorescence. In that case the bract is termed a *spathe*. In contrast with this is the case where a great number of small bracts are crowded together round a head of flowers, as in the Dahlia or Sunflower. Such a collection of bracts is called an *involucre*. In the common Globe Artichoke these bracts become succulent at the base, and constitute the edible portion.

[M. T. M.]

CHAPTER VIII.

REPRODUCTION—THE FLOWER.

DIFFERENCE BETWEEN GROWTH AND REPRODUCTION — POLLEN-CELLS — EGG-CELLS — CONDITIONS FOR FLOWERING — CONFORMATION OF THE FLOWER — PARTS OF THE FLOWER — FERTILIZATION — HYBRIDIZATION — SPORTS — DIVISION, SEPARATION, AND RECOMBINATIONS OF THE NUCLEAR ELEMENTS — SEEDS, DISPERSAL OF — GERMINATION.

It is necessary to bear in mind the distinction between growth and reproduction. Growth, as has been pointed out, takes place by extension or subdivision of old cells, and in the more highly developed plants by the formation of buds which are, or may be, the starting-points of shoots and branches. Sometimes also, as we have seen, these buds are separable and grow into plants which, though in a sense independent, are only subdivisions of the original plant. But in the process of reproduction an entirely new individual plant is produced by the co-operation and fusion of two originally separate nuclei or particles of protoplasm—the one male, the other female. The male protoplasm supplies the fertilizing substance or sperm, the female element is a detached portion of protoplasm called the egg, which is fertilized by the sperm. As a consequence of this union of two elements an *embryo* plant is produced. The embryo or seedling plant is thus a compound of two parents, and partakes of the characters of both, generally in different, rarely in equal, proportions. The essentials of fertilization are the same in all creatures, but the details differ very considerably in different plants. Here we are concerned exclusively with the higher groups, the so-called flowering plants, "Phanerogams", whose male cells, known as *microspores* or *pollen-grains*, are formed and contained within *microsporangies* or *anthers*, and whose female or egg-cells (*megaspores*) are contained within the *embryo-sac*, itself inclosed within an ovule.¹

CONDITIONS REQUISITE FOR THE PRODUCTION OF FLOWERS.

The production of flowers and of organs of reproduction depends partly on the same conditions as those which influence growth in general, but there are some differences to which it is of the greatest importance that the attention of the gardener should be devoted. Very gener-

¹ In some Cycads and Conifers fertilization is effected by spermatozoids as in Ferns, and thus a link is established between the Phanerogams and the so-called higher Cryptogams.

ally plants in a state of nature, left to themselves, do not flower till they have attained a certain age, an age very different in different cases. A so-called annual plant will flower and produce seed within a few weeks of its birth, whilst decades of years may pass before others are in a state to produce flowers. We are often content to attribute these differences to age, but that of itself is, of course, no explanation of the phenomenon. Gardeners in like manner attribute the development of the flowers to what they call *ripening of the wood*, and the phrase, though open to objection in form, is substantially true in fact. The ripening of the wood in autumn implies that the season, on account of its temperature more especially, has been favourable for the development of the tissues and for the formation and storage of food-materials. A relatively high temperature, together with an adequate supply of water and exposure to light, have been shown to be essential to the growth of the seedling plant, of the buds, and of the plant in general.

For the production of flowers it is generally observed that the quantity of water supplied should be lessened and the temperature increased. Many plants refuse to flower in this country, simply because they do not get enough heat, or a sufficiently long exposure to a high temperature and a bright light. Transfer these same plants to another climate, where heat and light are more abundant, and flowers will be produced. In this country we can, by means of glass-houses and hot-water apparatus, regulate the amount of water and of heat, but hitherto we have not been so successful in simultaneously adjusting the intensity of the light. The electric light, though at present too costly to be introduced into general practice, will eventually, no doubt, remedy this state of things, as it has been demonstrated that under its influence plants grow and fruits ripen with extraordinary rapidity. A time will come when experienced gardeners will be as well able to manage the lighting of their houses as they do now the heating, the water-supply, the shading, or the ventilation. Under existing circumstances, a period of rest or of diminished activity is desirable. Partly this is accomplished by the alternations of light and darkness, but more particularly by the diminution in the amount of heat and light, to which plants in the open are subject in winter, and under glass the diminished supply of water also. During this resting stage it must not be supposed that the plant is altogether dormant, unless, indeed,

the temperature is too low to allow of any activity at all. On the contrary, transpiration and respiration, as explained in former paragraphs, are going on, and those processes necessarily imply chemical changes which play an important share in the "ripening of the wood" and the formation of the flower. The methods employed by gardeners to promote flowering are, generally speaking, of such a nature as to check growth in general, and to compel the plant to turn its energies in the direction of reproduction. Thus, cramping the roots in pots, pruning the roots, laying the roots bare, bending the shoots downwards, diminishing the supply of food, especially of water, concurrently with a high temperature, are all means which have as their basis a diminished activity in the vegetative system of the plant. In the case of an annual plant, there is no resting stage other than that manifested by the seed, the amount of sun-heat, light, and moisture being sufficient to allow of the whole life-cycle being completed in one season. Possibly the introduction of the electric light used night and day will enable the gardener to induce continuous growth and the rapid completion of the flowering stage. That the plant subjected to such conditions will be the sooner exhausted, and die of premature old age, is likely enough, but this would be no disadvantage to the gardener, who could readily provide for that contingency by a continuous succession of reserve plants.

THE CONFORMATION OF THE FLOWER.

The simplest flower consists of a single *stamen*, or of a single *ovule*. In the vast majority of cases the arrangements are more complex, the stamens are invested by one or more coverings, and the ovule is invested by an *ovary*, and that by one or more coverings like the stamen.

Flowers are spoken of as *unisexual* when they are male, ♂, or female, ♀. When a stamen or stamens only occur in a flower, that flower is called a male flower; when an ovary or ovaries are present without stamens the flower is female. When both stamens and ovules occur in the same flower the flower is called hermaphrodite, and marked with the sign ♂. It must, however, be carefully borne in mind that though a flower be structurally hermaphrodite, it is not necessarily functionally so, the influence of pollen from another flower being generally desirable and sometimes essential, as will be explained later on.

In some cases male flowers and female flowers occur together, *e.g.* on the Cucumber plant, which

is then called *monœcious*. In other instances the male flowers occur in one individual, the female in another, as in the Willows. Under such circumstances the plant is spoken of as *diœcious*.

From what has been said it is clear that the essential parts of a flower are the stamens and the ovules respectively, and that these alone are absolutely requisite. But in most cases we find other parts added for the sake of protection, or with the object of promoting and facilitating fertilization in some cases, and of obstructing it in others. Botanists speak of complete flowers and of incomplete flowers. A *complete flower* is one which possesses (1) a

receptacle or *thalamus*; (2) a *calyx*; (3) a *corolla*; (4) one or more *stamens*; (5) one or more *ovaries* containing *ovules*. An "incomplete" flower is one in which some of the parts just mentioned are deficient. A "regular" flower is one in which the parts of each whorl are nearly or quite equal in size and alike in form, as in a tulip. An "irregular", sometimes called *zygomorphic*, flower, such as that of an Orchid, is one in which some of the parts of a whorl differ from the rest in size and form.

Speaking broadly, the parts of the flower originate like leaves, and are arranged in the same manner, generally in whorls, one whorl alternating with or coming between two other whorls. If the parts are very numerous, then they are usually arranged in a spiral manner, as may be seen in the "pips" of a strawberry. The parts of a flower may be all distinct and separate, or they may be partially, and to a very different extent in different cases, "inseparate". In the latter case the parts are said to be united, though in reality they have never been otherwise than whole. "Union" of this character, if between parts of the same whorl, is said to be *cohesion*. If the union, or more correctly the lack of separation, be between two whorls, the term *adhesion* is made use of. *Concrescence* is a term which includes both forms of apparent union. Coming now more particularly to the parts of a complete flower, as above defined, we have first to consider:

1. THE RECEPTACLE OR THALAMUS.—This is merely the extreme end of the flower-stalk. It is, therefore, the extremity of a branch or axis from whose sides are given off in regular order

the modified leaves which constitute the parts of the flower. The thalamus is usually not so conspicuous as to merit special attention, but in some cases it is greatly developed; thus, in the Rose Hip, the Apple, or the Pear, it swells out into a vase-like form and constitutes what in popular

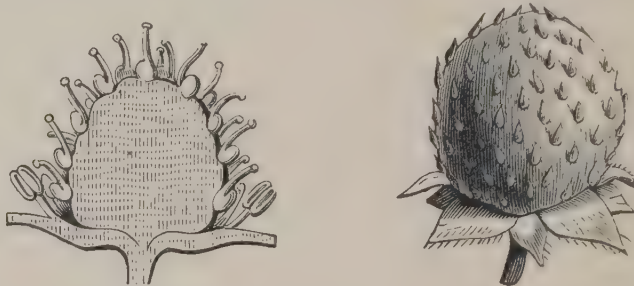


Fig. 59.—Strawberry—with Section, showing thickened receptacle bearing the true fruits or pips on the surface.

but inaccurate language is called the fruit. In other cases, it is prolonged above the flower, as in the ripened Strawberry, which, with like technical inaccuracy, is termed the fruit (fig. 59).

2. THE CALYX.—This is the outermost of the two coverings by which the stamens in a complete flower are enveloped. It consists of a number of pieces which receive the name of *sepals*. They are usually of a green colour like the leaves, which they also resemble in form, but are less highly developed. They are free, when the calyx is called *polysepalous*, as in a Buttercup; or they may be partially inseparate, when the calyx is called *gamosepalous*, as in a Gardenia. In the latter case the lower part of the calyx forms a *tube*, as in a Fuchsia, whilst the free portions collectively form the *limb*.

The office of the calyx is mostly to protect and shield the more important parts within from undue radiation or the direct effects of wet. Sometimes, as when invested with prickles or sticky hairs, it prevents the entrance of undesirable visitants.

3. THE COROLLA, PERIANTH.—Within the calyx and between it and the stamens in a complete flower is a whorl of

pieces which are called *petals*. They alternate with, or come between the sepals, and are usually of some other colour than green, and are, therefore, in so far, less like leaves than the sepals. Petals may be free, when the flower, as in the Rose or Strawberry,

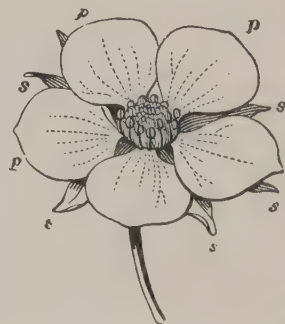


Fig. 60.—Strawberry Flower.

is said to be *polypetalous* (fig. 60); or inseparate, when it is called *gamopetalous*, as in a Primrose. In that case the corolla has a *tube* and a *limb*, as the calyx has under like circumstances. The

form of the corolla may be strictly *regular*, as in a Primrose; or *irregular*, as in a Snapdragon. This irregularity is connected with the visits of insects to obtain honey or pollen and, as a

such cases the term *perianth* is used instead of calyx or corolla.

4. THE STAMENS.—Within the corolla are the stamens, collectively constituting the *androecium*.

A stamen usually consists of a “filament” or stalk, which supports a case containing yellow dust; this case is a *sporangium* called the *anther*, and the yellow dust is made up of separate cells generally called “pollen-grains”, but now known to be the equivalents of the *microspores* of the lower plants, and which are very varied in shape in different plants (fig. 63). The pollen-grains escape from the anthers either by longitudinal chinks in the side, or through pores at the top as in Heaths. The stamens vary in number, position, length, and form. The most important differences are those concerning their relative position. They are free or distinct from any other parts, as in the Poppy; or they may be in union with the calyx, *episepalous*, or with the corolla, *epipetalous*. When quite free from one another and from other parts they are *hypogynous*, as in

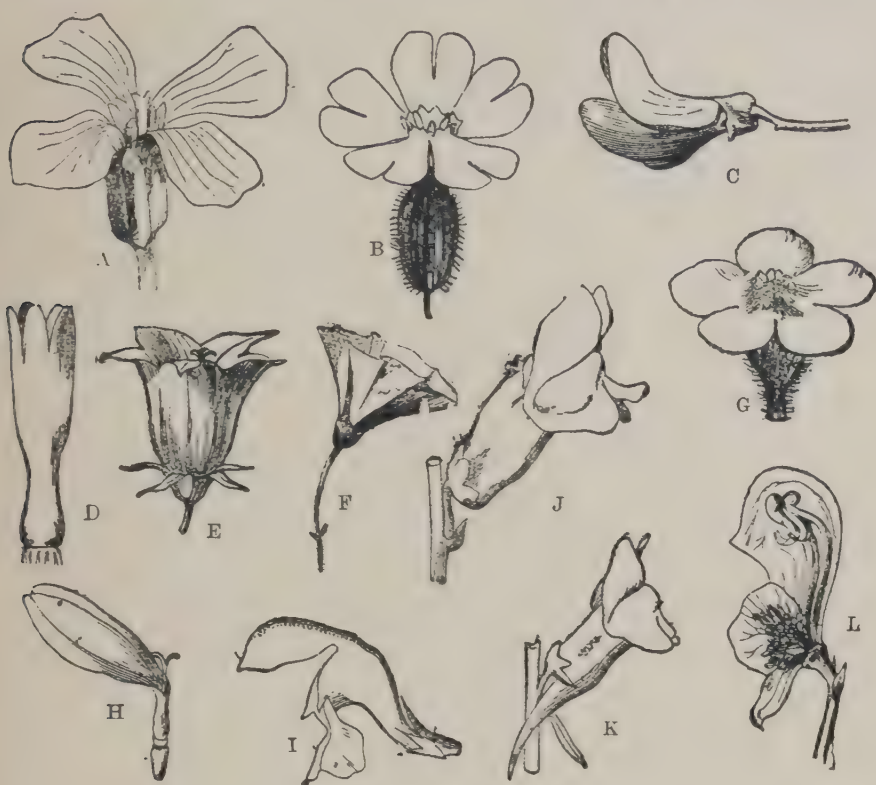


Fig. 61.—Forms of Corolla.

A, Cruciate. B, Caryophyllaceous. C, Papilionaceous. D, Tubular. E, Campanulate. F, Funnel-shaped. G, Rotate. H, Ligulate. I, Labiate. J, Personate. K, Personate and spurred. L, Nectaries.

consequence, to transfer the pollen to some other flower. The colour and fragrance of the corolla offer obvious attractions to insects. The various forms which the corolla may assume are very numerous. We can here only indicate the general principle of their construction, and leave the details to be sought for in botanical text-books (fig. 61). A compound flower is one which consists of a growth of flowers or florets closely crowded in heads within an involucre of bracts, as in the Dandelion (fig. 62).

Generally it is easy to discriminate between the calyx and corolla by their position alone, but there are a few cases where it is difficult to do so, and there are cases where the calyx is brightly coloured, as in *Daphne Mezereon* or where calyx and corolla are alike in colour, as in Lilies, Tulips, &c. In



Fig. 62.—Inflorescence of Dandelion.

the Vine; when they are partly separate only from the calyx they are *perigynous*; whilst in some cases they remain so closely blended with the tube of the corolla or the tube of the calyx, and that in its turn is so joined to the ovary that the stamens appear to come from its top, when the term *epigynous* is applied, as in the Carrot and other Umbelliferae. Plants having free hypogynous stamens are called *thalamifloral*; where they are partially inseparate from the calyx they are called *calycifloral*; when partially inseparate from the corolla, *corollifloral*; when partially inseparate from the ovary, *epigynous*; or when completely blended with the upper part of the ovary and styles, *gynandrous*, as in the Orchid family.

The varied form and arrangement of the stamens have generally a direct relation to the protection of the pollen from injurious agencies; sometimes to its effectual dispersal and removal to another flower—cross-fertilization; whilst at other times the arrangements are such as to facilitate the access of the pollen to the stigma of the same flower, and so bring about close-fertilization (fig. 64). For other details relating to the stamens reference should be made to the ordinary text-books.

5. THE PISTIL.—The centre of a complete flower is occupied by the *pistil*, which consists

of one or of more *carpels*, each carpel in its complete condition consisting of an *ovary* or lower portion, which is a hollow case from and within which the *ovules* originate. The ovary is frequently prolonged upwards into a little shaft called the *style*, at or near the top of which is a little space devoid of epidermis, and generally

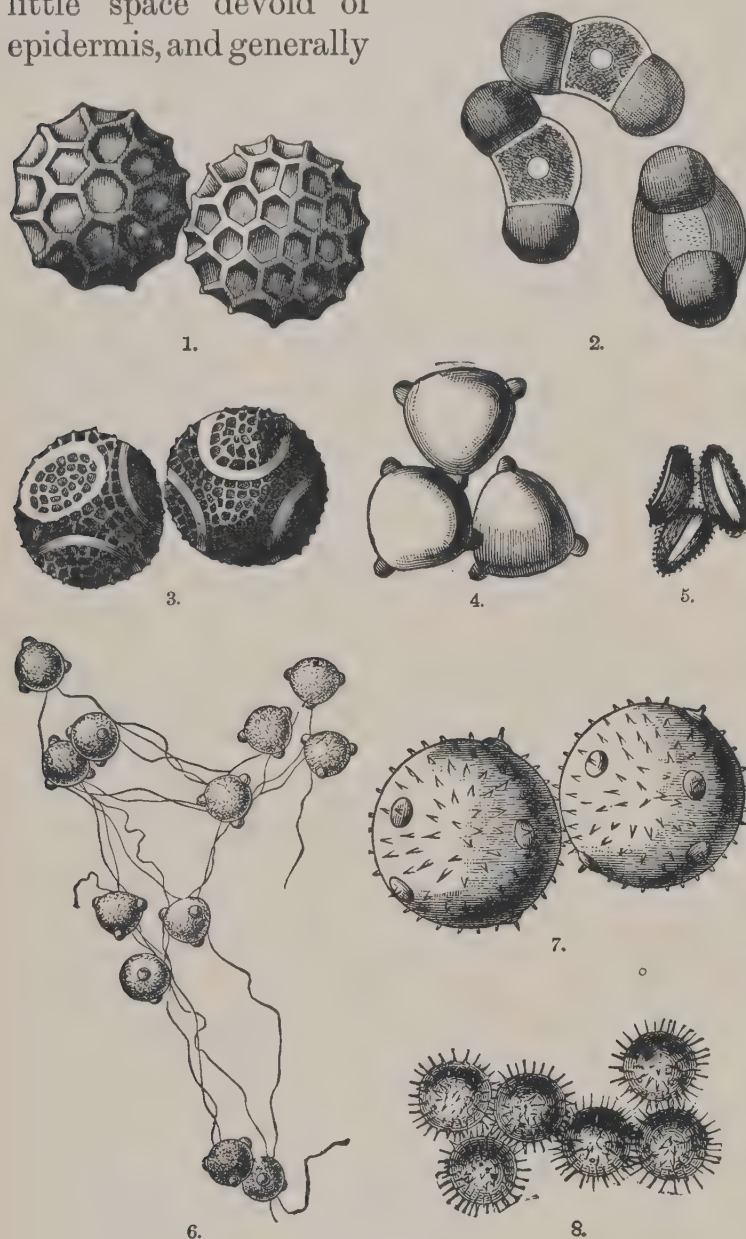


Fig. 63.—Pollen-cell.

1. *Cobaea scandens*. 2. *Pinus Pumilio*. 3. *Passiflora kermesina*. 4. *Circea alpina*. 5. *Nymphaea alba*. 6. *Epilobium angustifolium*. 7. *Cucurbita Pepo*. 8. *Hibiscus ternatus*.

secreting a little mucous fluid—this is the *stigma*. Where there is no style the stigma is said to be “sessile”.

The *carpels*, whether solitary, as in the Pea, or in groups, are either entirely free, as in the Buttercup; or more or less inseparate one from the other or from the other parts of the flower, just as is the case with the stamens; or they may be inclosed within, or even embedded in, the substance of the thalamus, as in the case of the Cucumber. When the ovary is free it is spoken of as *superior*, but when inseparate from the calyx, so that the calyx appears to be at the top of the ovary, the term *inferior* is made use of. Superior and inferior here refer to the apparent relative position of the ovary

and the other parts of the flower. Originally the ovary, as being the last formed, is always above the other parts of the flower, but the real position is often obscured by adhesions, by concrescence or inseparation, or by the development of the thalamus in the form of a cup or tube at the bottom of which the ovary is placed, as in the Plum or Cherry. Sometimes the tube of the receptacle and the walls of the ovary are concrescent, so that the two organs become inseparable, as in the Melon or Cucumber.

When several carpels are coherent by their edges (“sutures”), or by their infolded sides, the ovary is spoken of as “compound”, and when cut across it shows as many compartments as there are ovaries, the compartments being separated by the infolded sides of the ovaries, which are now called *dissepiments*. But when the edges of the carpels unite without being infolded, we

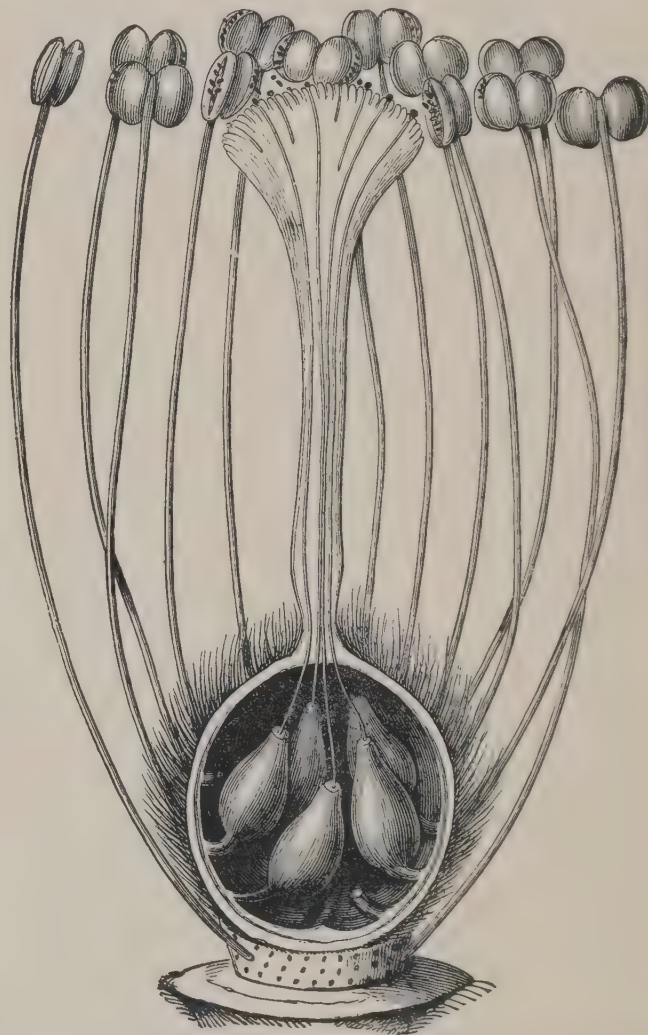


Fig. 64.—Flower of *Cistus*: Sepals and Petals removed. The Stamens are hypogynous, and some of them have their Anthers in contact with the Stigma. The Pollen-tubes are shown passing down the Style and entering the Ovules.

may get a compound ovary with but a single cavity. In such cases we are generally able to ascertain the number of the constituent carpels by counting the styles or stigmas, which are rarely so completely blended as the ovaries.

6. THE OVULES.—The ovules are the immature seeds, formed as projections from the walls or edges of the ovaries, the special portion from

which they spring being known as the *placenta*. Sometimes there is but one ovule, and this may be at the base, side, or top of the ovary, and erect or pendulous, straight or curved. Generally the ovules are numerous, and if springing from the edges of a single carpel, as in a pea, the placenta is said to be *sutural*; if from the infolded dissepiments of a compound ovary, the placenta is said to be *axile*, as in an Apple or Lily; whilst if the ovules spring from the walls of the cavity, the placenta is called *parietal*, as in a Poppy. In the Primrose the ovules are borne upon a little column which stands up in the centre of the ovary detached from its walls. This form of placenta is spoken of as *free central*.

The ovule consists of a central mass, the *nucellus*, surrounded by one or by two "coats" which grow up over the nucellus from the base upwards, being at first mere rings which lengthen into tubes, and eventually cover the whole of the nucellus with the exception of a small opening at the top called the *micropyle*. When the ovule is straight it is usually erect and sessile, but when it is curved or inverted it is said to be *anatropal*, in which case there is a stalk called the *raphe* intervening between the base of the ovule and the placenta, as may easily be seen in a Pea or Hazel-nut. In the interior of the nucellus is one large cell called the *embryo-sac*, which contains the egg-cell or germinal vesicle (fig. 66). This, when fertilized by contact with the generative nucleus formed in the pollen-grain, develops into the embryo plant. In addition to the egg-cell the embryo-sac contains other cells and nuclei, the nature and functions of which are not fully ascertained. Mention may, however, be made of the two *polar nuclei*. These are at first free in the embryo-sac, but at or after the period of fertilization the two polar nuclei coalesce to form one cell, and from this cell is ultimately formed the *endosperm* or *albumen*. The other contents of the embryo-sac are perhaps rudiments of an ancestral state, and may eventually furnish links in the course of descent from pre-existing forms, or points of similarity with other forms as yet not made out.

FERTILIZATION.

The essence of this process, the details of which are very complex and still the subject of inquiry, consists, as has been previously stated, in the fusion of two previously separate masses of protoplasm; the one, the male nucleus, acts as the fertilizer and is derived from the pollen-tube; the other, the female nucleus or *oosphere*,

is formed in the embryo-sac. When fusion takes place between the two nuclei the *oosphere* becomes the *oospore* or egg, from which the embryo or seedling plant is in due time developed. In addition to the fusion of the two nuclei, it is stated that a small portion of the protoplasm from the pollen-tube fuses with a corresponding portion of the protoplasm in the embryo-sac. In any case we have a blending of two heretofore separate things into one.

The plant has thus the power of vegetative propagation by means of spores or aggregations of spores in the shape of buds, and of fertilization by the fusion of male with female spores.



Fig. 65.—Section of Style of *Lilium Martagon*, showing Pollen-cells on the Stigma, and sending down their Tubes along the conducting tissue of the Style.

Pollination is the name given to the transfer of the pollen-grains from the anther to the stigma. When deposited on the stigma, and provided that organ be moist and in a receptive condition, the pollen-cell commences to sprout, and sends down a long slender tube through the style into the ovary (fig. 65). This process may occupy a long time, several months in the case of conifers, and during that time the tube not only grows but is nourished, partly on the contents of the tube, partly on food obtained from the style, a ferment being formed which effects the solution of the food material and enables it to be absorbed. The pollen-tube forms from its protoplasm three nuclei: one is called the vegetative nucleus, and has no part in the process of fertilization, the other two are smaller, and are known as the generative nuclei.

Arrived in the ovary the pollen-tube comes

into contact with the ovule, enters the *micropyle*, and impinges upon the embryo-sac. One of its generative nuclei in some way enters the sac and comes into contact with the female nucleus as

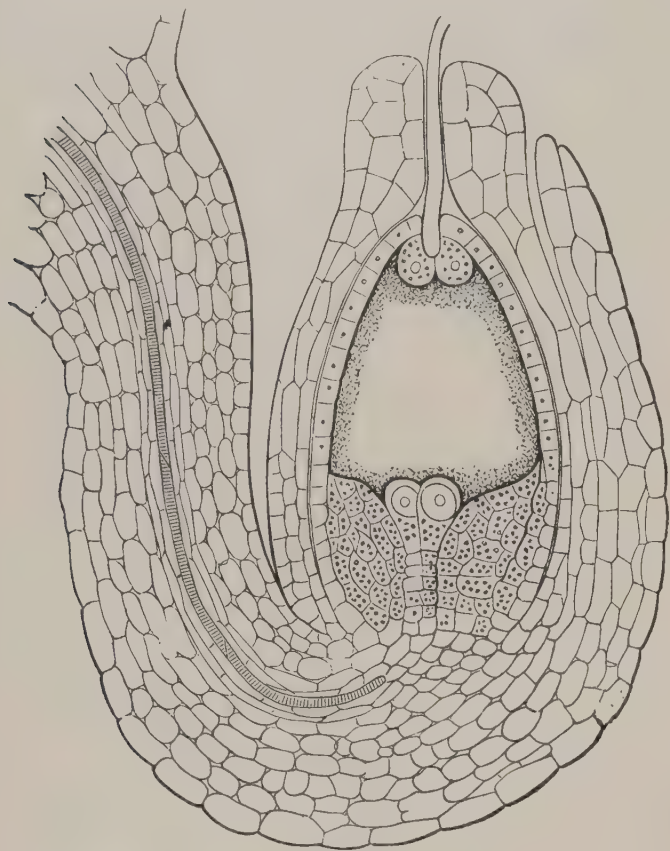


Fig. 66.—Section of an Ovule, showing the entry of the Pollen-tube into the Embryo-sac.

before stated, the other generative nucleus shrivels and disappears.

Where pollen falls on the stigma of the same flower what is termed *autogamy* or *close-fertilization* ensues, and this is necessarily the case in flowers that do not open, and are hence called *cleistogamous*. More often than not close-fertilization is prevented by the circumstance that the stigma of the flower yielding the pollen is not mature at the time the pollen falls on it, and so no germination of the pollen-tube takes place, or, in any case, its male nucleus does not reach the egg-cell. What generally happens is that the pollen of one flower is deposited on the stigma of another flower on the same plant, or another plant of the same species. This is termed *cross-fertilization*. The means by which the pollen is conveyed from one flower to another are manifold: sometimes it is carried by the wind, and this is the explanation of the sulphur showers sometimes spoken of, the so-called sulphur being the pollen, generally of pine-trees, which is produced very abundantly, and is blown in showers by the wind.

Insects are the most frequent pollen-carriers. Attracted by the bright colours and fragrance of the flowers, they visit the flowers for the sake of the nectar they contain, or some of them for

the sake of the pollen itself. In either case, if circumstances permit, the insect readily conveys the pollen to the stigma of the same flower or to those of some other flowers.

The astonishing diversity in the shapes of the flowers and the varying relative lengths of the stamens and styles are, many of them, as has been pointed out, explicable by the fact that they are "adaptations" which so facilitate the access of insects and direct their passage in one flower as to compel the unconscious insect to remove the pollen, and in corresponding ways to deposit it on the stigma of another flower (fig. 67). This doubtless also accounts for many curious forms of flowers, the hairs, the warts, the grooves, the springs, the mechanical contri-

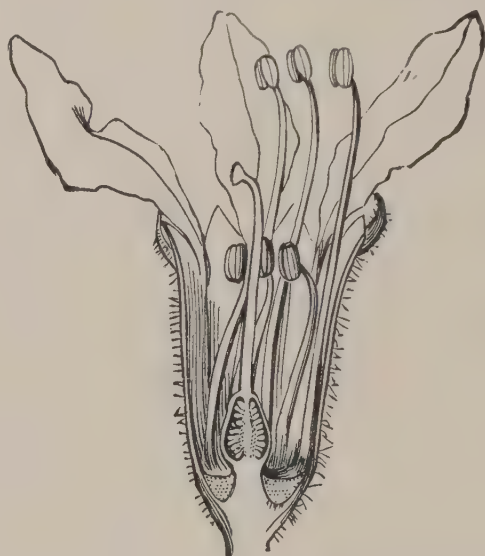


Fig. 67.—Lythrum. Section of Flower showing two rows of Stamens—one short, one long. The Style is short.

vances, and the endless means by which insects are compelled to go in the particular track best adapted to secure the removal of the pollen and its deposit on the stigma. Often the mechanism seems to be adapted to one particular sort of insect, and if that be absent or not forthcoming, the flower cannot be fertilized. This is one reason why certain exotic plants do not produce seed in this country.

Whilst the mechanism of the flower is in many cases so developed as to necessitate the co-operation of insects in order to secure the production of new plants, in other cases analogous mechanism is developed to exclude those insects which are not wanted or which would be injurious. This seems to be the meaning of those glandular, sticky hairs by which the flower-stalk or the calyx of some flowers is invested. A similar purpose is served by a coating of hairs pointing downwards, and thus preventing access of crawling insects. A brightly-coloured, fragrant, or an "irregular" flower may always be considered as adapted for insect agency.

In Passion-flowers and some other plants fertilization cannot be effected by a flower's own pollen even when carefully deposited by the experimenter. The flower indeed in such cases refuses to be fertilized by its own pollen, and requires the application of that of some other nearly allied species. But, on the one hand, close-fertilization may sometimes occur, and on the other hand an occasional cross may be effected in flowers that are habitually close-fertilized. On the whole, cross-fertilization is advantageous, and secures a larger proportion of continuously healthy seedlings than does close-fertilization, or "in-and-in breeding".

Artificial fertilization is sometimes practised in gardens, when the pollen is removed with a camel's-hair brush and applied to the stigma of the same or some other flower of the same species.

HYBRIDIZATION.

This differs from cross-fertilization only in degree. Cross-fertilization occurs between two separate flowers of the same individual plant, or between flowers of different individual plants of the same species. Hybridization is the fertilization of the flower of one species by the pollen of the flower of another species. Generally speaking the two species must be nearly allied, the more nearly so the more likely is the cross to be effected, the wider the difference the less likely is the cross to be successful. No doubt hybridization does occur in nature, but it is not common. A proof that it does occur is offered by some Orchids and Narcissus. These particular forms when first introduced were supposed to be hybrids from their combining the characteristics of two species. When the two parent species were known to grow in the same locality the inference was strengthened. But the case has now been demonstrated in gardens by the hybridizer actually producing the same form by fertilizing artificially the one flower by the pollen of the other.

To effect hybridization great care is necessary to prevent the pollen of the flower to be hybridized from gaining access to its own stigma; hence hybridizers are careful to remove the stamens of the flower they are operating on, and to cover up the flower with muslin after the operation, so as to prevent the entry of insects.

When it is desired to keep any particular "stock" true, it is desirable—in some cases imperative—to grow no other plants of the same nature in the vicinity. The flowers of the

cabbage genus (*Brassica*) are specially liable to intercross in this way if care be not taken to keep the stock true in the manner indicated. Cross-breeding and hybridization form most valuable means to the gardener for the production of new forms; but inasmuch as it often happens that the cross or the hybrid is not so good as either of its parents, it is specially desirable that the crossing should not be done hap-hazard, but that the cross-breeder should formulate in his own mind, before operating, what results he wishes to obtain, and then select those plants for crossing which are the most likely to ensure the results he desires. A vast number of mongrel seedlings which are now raised are practically worthless, and entail disappointment and loss of time to the raiser. These evils might largely, if not entirely, be obviated by a more systematic course of procedure. In any case accurate records should be kept, and every care taken to ensure success. Nor should the hybridizer be discouraged by want of success in the first instance. A first cross often results in the appearance of a number of unattractive or useless forms, but by continuing the process of crossing, and selecting for breeding purposes only the best and most suitable, the desired results may in many cases be secured. (See also chap. ix.)

SPORTS.—The appearances presented by cross-breds and hybrids are very often difficult to be accounted for. Still more mysterious is the sudden appearance of *sports* or *bud-variations*. These latter may in some cases be accounted for by the separation of the heretofore mixed characteristics. The changes that occur in the nuclei in the course of their subdivision may also eventually furnish an explanation. These changes are very complex and obscure, so that they can only be briefly alluded to. It must suffice to say that the nucleus consists of a number of curved threads closely interwoven (fig. 68). When the nucleus divides it not only does so transversely, so that two groups of threads are formed, but each thread divides lengthwise. In the process of fertilization, as we have seen, two nuclei coalesce into one; that one must necessarily be formed of the threads belonging to its two predecessors. When its turn comes to divide, its threads divide, as we have seen. Generally speaking the division is quite equal, each subdivision containing an equal number of threads. But it is quite conceivable that this accurate distribution may sometimes not happen, and then we should get divisions not of equal nature, and from this primordial inequality what

we know as "sports" may originate. But this is, of course, at present merely conjectural. (See also chap. ix., p. 58.)

THE FRUIT.

Generally speaking the term *fruit* means the ovary or pistil of any flower that is more or less

modified subsequently to and consequently upon fertilization. The fruit or pod of a Bean or a Pea is thus merely the ripened ovary.

In the course of ripening various changes occur. Sometimes the outer portions become soft and succulent, as in the Gooseberry or the Grape. Such fruits are loosely called *berries*. At other times the inner layers of the ovary



Fig. 68.—Changes in the Protoplasm of the Cell-nucleus during its Division.

1. The Nuclear Fibrils distributed through the whole Nucleus. 2. The broken-up Nuclear Fibrils arranged as the Nuclear Plate. 3. The elements of the plate separating from one another. 4. The same elements forming two skeins at the poles of the Spindle. (After Guignard.) Very highly magnified.

become hard by the deposit of woody matter, and a stone-fruit or *drupe* is the result, as in the Plum or Cherry (fig. 69). In a third class of examples the fruit as it ripens dries up, and eventually forms a case which cracks open or "dehiscens" to set free the seeds. Such a fruit is called a *capsule*. The capsule may, when ripe, split longitudinally into a number of *valves*, which separate to liberate the seeds, or exit for those bodies may be provided for by small holes or pores, as in the Snapdragon. If the capsule have but two valves—in other words, if it consist only of a single carpel splitting along both edges—it is called a *legume*, a familiar illustration of which is afforded by the common pea-pod, and which gives the name Leguminosæ to a large order of plants characterized by the possession of a fruit of this nature. If the single carpel bursts along one edge only it is called a *follicle*. Dry fruits which do not open are spoken of as *indehiscent*, and may roughly be called *nuts*.

During the ripening process great changes may occur in the other parts of the flower as well as in the carpels themselves, to some of which we must refer. Thus, in the case of the Apple or Pear, the upper part of the peduncle or flower-stalk, the receptacle in fact, becomes much

enlarged, whilst the *core*, which is the true fruit, is embedded in its fleshy substance. The edible portion or *pome* of an Apple or Pear is therefore not the fruit, though so called popularly.

In the Fig the true fruits are the minute pips found in the interior of a swollen receptacle analogous to that which forms the pome. In the Strawberry the true fruits are the small pips which people generally consider to be seeds, the edible portion is the enormously dilated receptacle (fig. 59). In the Raspberry and Blackberry the receptacle remains relatively small, but the carpels develop into small succulent *drupes*, like those of the Cherry, but differing in size and in the fact that they are aggregated into a mass instead of being solitary.

Sometimes the fruit consists not only of the modified portions of one flower, but of an aggregation of flowers. A Pine-apple or a Mulberry, for instance, is the result of the ripening not of one flower only, but of a whole inflorescence or spike—bracts, perianth, and carpels becoming all of them more or less succulent and blended into one common mass.

The object of these various changes in the ripening of the fruit may be considered to be the dispersal of the seed. In the capsular fruits the seeds are often ejected with some force, whilst the succulent fruits are eaten by birds and the seeds thus scattered.

Frequently the seeds or the seed-cases are covered with hooks, as in burrs, which become entangled with the coats of animals or the

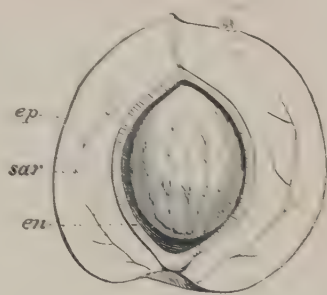


Fig. 69.—Section through the Fruit (Drupe) of a Plum, showing the Epicarp *ep* or Skin, the Sarcocarp *sar* or Flesh, the Endocarp *en* or Stone. In the centre is the solitary Seed or Kernel.

plumage of birds, and so the dissemination is effected (figs. 70, 71).

The chemical changes which occur during the ripening of the fruit are varied and complex.



Fig. 70.—Seeds showing the Outer Skin or Testa with rugged prominences or projections. The sections show the Seeds cut lengthwise, and show the Embryo with its two Cotyledons, and the Radicle surrounded by the Perisperm.

All the time that it remains green it has the same functions as other green members, but afterwards in succulent fruits starch is converted into sugar, various acids and other compounds are formed which confer flavour on the fruit, the explanation of which pertains to chemistry.



Fig. 71.—Seeds with the Testa or Skin winged, or provided with a tuft of Hairs, the object in each case being to secure the dispersal of the Seed.

The same conditions as for growth generally influence the formation of the fruit, but a larger amount of heat and a fuller exposure to the sun are required for the full development of the fruit than for the leaves; hence it is that many tropical plants can be made to grow here though not to produce flower or fruit.

The whole art of forcing depends on the recognition of the facts just stated.

SEEDS, GERMINATION.—As the fruit consists of the ovary or ovaries of the flower in a mature state, so the seeds are the ovules ripened in consequence of fertilization (see p. 53). The coats of the ovule become the coats of the seed, sometimes dried up, at other times rendered succulent. The nucellus frequently disappears as the embryo grows, or it persists and supplies food for the seedling plant. When it remains it is called the *perisperm* or *albumen*, and a seed like that of Wheat, which is provided with such tissue, is spoken of as *albuminous* or *perispermic*, in contradistinction to an *exalbuminous* or *aperispermic* seed, as in the Pea or the Almond. The embryo-sac also gets filled with a similar tissue, which is called the *endosperm*, produced from the fusion of the two “polar nuclei”, and this also may or may not be used up as the embryo plant grows. The number of seeds produced, and their form, vary greatly in different plants, these variations being largely connected with the preservation, protection, or dispersion of the seed.

When the seed with its contained embryo or seedling is placed under propitious circumstances growth commences, the seed, or, more correctly speaking, the seedling begins to germinate, the process having been previously described, see p. 32. The circumstances propitious to germination are: sufficient moisture, an adequate amount of heat, and access of oxygen. When these conditions act conjointly the seed-coat swells, the cells of the embryo plant multiply, chemical changes occur which result in the transformation and solution of the food-stuffs stored up in the perisperm or it may be in the tissue of the seedling plant itself. In some cases, perhaps all, the transformation of inert into available matter is effected by an *enzyme* or ferment secreted in the tissues of the seedling, so that the growth of the embryo is the consequence of changes analogous to those which occur in the digestion of nitrogenous matters by the leaves of the so-called insectivorous plants, and to those which effect the digestion of starchy and other matters in the stomach and intestines of animals and of mankind. That there should be any analogy between the growth of a seedling plant and the digestion of our own food is not apparent on the surface, but it is, nevertheless, strictly true, and it is only one of many illustrations showing that the life of plants is, in essence, identical with the life of animals and with our own. The elementary construction is

the same, the origin is the same, the phenomena of nutrition and of reproduction are substantially the same. Wherein, then, lies the difference which makes us consider ourselves "lords of the creation"? Chiefly in this, that we are more or less conscious alike of our relations to those creatures less highly endowed than ourselves, and to the supreme First Cause to whom both they and ourselves owe existence. [M. T. M.]

CHAPTER IX.

HYBRIDIZATION.

CROSS-FERTILIZATION—HYBRIDISM—ISOLATION AND SELF-FERTILIZATION—DOUBLE FLOWERS—FERTILIZATION IN CRYPTOGAMIC PLANTS, FERNS—VEGETATIVE SPORTS OR BUD VARIATION.

Theophrastus of Eresus (born B.C. 390) was the first author to refer to the fertilization of dioecious plants. Both Theophrastus and Pliny, who wrote in the first century of our Christian era, allude to the practice of hanging the male or pollen-bearing inflorescence of the Date-palm on or amongst the groves of fruit-bearing or female trees. The custom of "caprification", as applied to figs, consisting in hanging branches of the wild fig-tree and its attendant fertilizing insect upon the cultivated or fruit-bearing kinds, is also of great antiquity. In these, as in innumerable other instances, practice, or common usage amongst cultivators, has been ahead of science, or the philosophical explanation of things really done.

Camerarius first clearly showed the dual sexuality of flowering plants (*v. Linnæus, Amœnitates*, i. 62) in the years 1691–1694, when he published his actual experiments with Ricinus (Castor-oil), Mercurialis, Maize or Indian Corn, and Cannabis or Hemp plants.

In England Bradley in his *New Improvements in Gardening* (1717), i. 20, refers to his having emasculated twelve Tulip flowers, all of which proved seedless, while four hundred Tulips in another part of the garden bore good seeds. A friend and correspondent of Bradley's named Thomas Fairchild had a nursery-garden and vineyard at Hoxton (1722), and he is believed to be the raiser of the first garden hybrid or "mule", viz. "Fairchild's Mule Pink", which was presumably a cross, raised prior to 1705, between a Carnation and the common Sweet-William (*Dianthus barbatus*). At a later date the celebrated Philip Miller of Chelsea emasculated or removed the anthers of twelve

Tulips in his garden, but he observed that the bees brought the pollen of other Tulips and fertilized them (*v. Gard. Dict.*, part ii., Tulip, 1751). He also observed that female Spinach plants growing apart from the male plants bore large seeds, but these developed no embryos. Morland in England and Geoffray in France also made similar observations, as also did Koelreuter as to insects carrying the pollen from the male to the female plants of Mistletoe, and the same observer was the first person on the Continent to rear hybrids between various species of Nicotiana, Matthioli or Stocks, Dianthus, and Hyosecyamus and Verbascum. C. K. Sprengel first observed the fertilization of orchid flowers by insect agency at Spandau prior to 1793. Sprengel also contributed largely to the then new knowledge, while in England T. A. Knight, Dean Herbert, and on the Continent K. F. Gärtner did much to strengthen Sprengel's views and experiments.

Knight was one of the first to improve our garden peas by cross-fertilization, and as a result he laid down the principle that no plant can fertilize itself through unlimited generations without suffering in vigour and fertility.

Herbert, who experimented largely with Amaryllidaceous plants (*v. Amaryllidaceæ*, 1837, and his article on "Hybridization amongst Vegetables"), also came to the conclusion that pollen from other individual plants, or, at least, from other flowers, gave far better results than self-fertilization. To crown all came Charles Darwin, who, in 1859, published his wonderful *Origin of Species*, in which he summed up nearly all that had been observed and recorded, and by collating the work of Koelreuter, Knight, Herbert, and Gärtner with the views of Sprengel opened up our modern vistas of knowledge, and proved beyond a doubt the great central fact that "Nature abhors perpetual self-fertilization".

In one word it may be said that cross-fertilization or hybridism lies at the very root of all upward and onward progress (evolution) in field and garden crops alike, and by their aid nearly everything desired by the cultivator may be effected. Good culture and careful selection may work wonders alone, but it is to judicious cross-fertilization and hybridization that most of our improved races, breeds, or strains of fruits, vegetables, and flowers are due. In proof of this we have only to look on the old drawings, or specimens, of wild Fuchsias, Calceolarias, Cinerarias, Pelargonias, Ericas, Dahlias, Chrysanthemums, Begonias, Cannas,

and Cyclamen, &c., and compare with them the garden forms existent to-day. In habit, size, form, and colour there are vast improvements from the horticulturist's point of view. The same is true of our finest fruits and vegetables, such as Apples, Pears, and Plums, Cherries, Peaches, and Grapes, or Cucumbers and Toma-

atoes. In a word, man has adopted Nature's own tactics in the garden. Like the fly or the bee, he carries pollen from flower to flower, but with *deliberate intent*, and so he can in many cases readily vary or alter his crops, and render them more amenable to the particular ends he has in view.

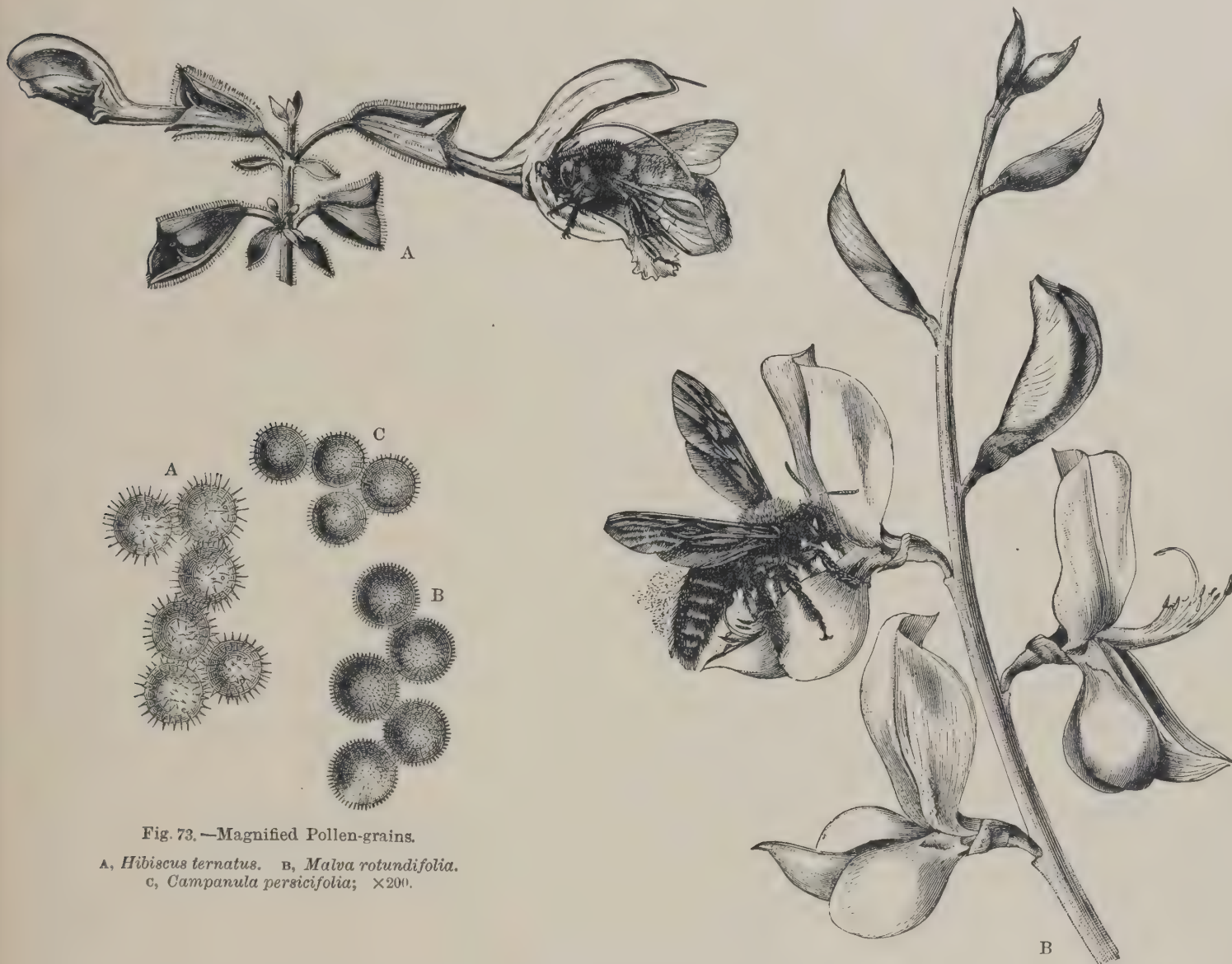


Fig. 72.—Bees and Flowers.

A, Part of an inflorescence of *Salvia glutinosa*; the right-hand flower is being visited by a humble-bee, and the pollen-covered anther is in the act of striking the insect's back. B, *Spartium scoparium*; in the lowest flower the keel is still closed and stretched out horizontally; in the flower next above, the keel is depressed and the stamens have sprung up; the third flower is being visited by a Carpenter Bee (*Xylocopa violacea*), and is ejecting its pollen on to the under surface of the insect's body. (Kerner.)

The three great factors in plant improvement are good cultivation, judicious cross-fertilization, and rigid or careful selection.

When it comes to actual practice, all that man can do is to place the pollen from the anthers of the male parent selected upon the stigmas of the plant selected to bear the seeds. The hybridist applies the pollen and nature does the rest. The hybridist will probably have to deal with three types of flowers, viz. (1) hermaphrodital, (2) monœcious, and (3), diœcious. The first type consists of all those flowers which have stamens and pistil included in the same flower, as in Roses and Lilies. The monœcious, or unisexual flowers, have male and

female flowers separate from each other on the same plant, and are represented by Begonias, Cucumbers and Melons, Ricinus, &c. Diœcious plants are those having male and female flowers on distinct and separate plants, such as Aucuba, Cannabis (Hemp), Spinach, and Humulus or the Hop-plant.

In the case of hermaphrodital flowers, however, we in many cases find some provision made in order to prevent autogamy or self-fertilization. In some cases the flower is protandrous, *i.e.* the anthers ripen and shed their pollen long before the stigmas of the same flower are fit for fertilization. In other cases the flowers are protogynous, *i.e.* the stigmas

are receptive, and are often fertilized by pollen from other flowers long before their own anthers are ready, or their pollen ripe. Then, in other cases, flowers of two or three kinds, *i.e.* dimorphous or trimorphous, are borne by the same plant, or even on the same inflorescence, as in *Primulas*, which have long-styled and short-styled flowers, or *Lythrum*, which has trimorphous flowers, or as in the case of some orchids such as *Catasetum*, in which male and female and hermaphrodite flowers are all occasionally borne. In this way we see that even hermaphrodital flowers often obtain the advantages gained by those which are monœcious or dioecious, and as a broad rule all such flowers are more predisposed for cross-fertilization, and so, as it were, lend themselves to the gardener's or hybridizer's hand.

After pollination, *i.e.* after the pollen-grains have been applied to the stigma, it in a sense begins to grow. A very slender thread-like tube is protruded from each little pollen-grain, and these tubes grow, *i.e.* they force themselves, or are attracted down through the soft and spongy

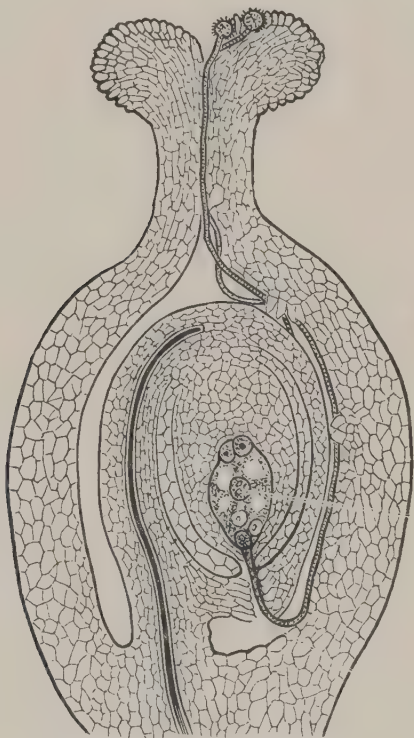


Fig. 74.—Longitudinal Section of a Pistil, with a Single Basal and Anatropous Ovule, showing the course of the Pollen Tube.

tissues of the style or pistil, so as to eventually reach the ovules or young seeds (fig. 74).

The growing point of the pollen-tube enters the ovules by a little aperture called the micropyle, and in this way a union is effected between the sperm matter of the pollen and the germ matter of the young ovule (fig. 75). In other words, the ovule becomes fertilized, and begins its development as a seed containing a living germ or embryo that contains within itself the

united characters of its two immediate parents, and also hereditary traits derived from some at least of its many former ancestors. In this way

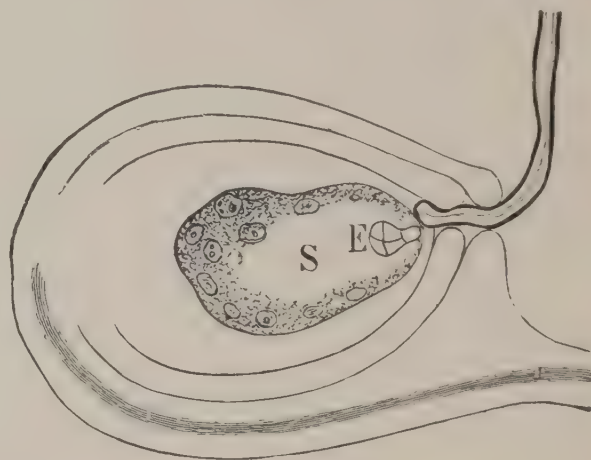


Fig. 75.—Ovule after fertilization. S, Embryo-sac with developing endosperm. E, Embryo. (After Prantl and Vines.)

pollination may take place without fertilization, but, on the other hand, it is impossible for fertilization to occur unless pollination has taken place. Of course it is necessary for pollen to be fully developed or ripe, a fact generally known by its escape from the slits or pores of the anthers. On the other hand, the stigma or the stigmatic surface to which the pollen is applied must be what is called receptive, *i.e.* in a fit state of development to receive it.¹

There is, as a rule, no great difficulty about the practical art of cross-fertilization or hybridism. The first thing is to decide exactly what you desire to obtain as the progeny of any two species of the same genus, or between any two varieties of the same species, and then at the right time you transfer the pollen of the one parent to the stigmas of the other. This is simply what the bees and the flies have done for ages past, unconsciously no doubt, in their search for wax and honey. But it is often desirable, and sometimes absolutely necessary, that the anthers of the female parent should be cut out and removed before they shed their pollen, so as to make sure that the stigmas are not fertilized by the pollen of the same flower, for if this should have taken place the application of any other pollen will be useless or misleading. This removal of the anthers of a seed-bearing flower is called emasculation.

The implements and appliances needed are very few and simple. A good pocket lens and a pair of small long-handled surgical scissors are useful; so also is a needle thrust into a slender handle, which is better than knife or scissors for slitting up tubular flowers. A few neat little

¹ The figs. 55, 56, 57, and 59, in the preceding chapters, should be referred to in connection with the subjects of pollen, pollination, and fertilization.

bits of bamboo, pointed like toothpicks and of different sizes, are also useful, and are cleaner and more satisfactory than camel's-hair or sable pencils for conveying pollen from anthers to stigmas. Before using these they should be dipped into some nectariferous flower, a Fuchsia for example, as this honey causes the pollen to adhere and also facilitates its growth. Small muslin bags will be needed in many cases to protect the impregnated flowers and prevent pollen being blown or carried by insects to those selected for seed-parents and fertilized or pollinated by some particular pollen.

Then when many crosses are made we should enter full particulars of them into a note-book and affix to the plants small tallies or labels having corresponding date and number, so that we can at once verify every cross or pollination made. Without this precaution chaos will soon reign supreme, and we shall be quite unable to say accurately what the parents of our hybrids or crosses really were.

Much as has been already done by our leading horticulturists in the fertile field of hybridism, much more remains to be done, and many, many more earnest workers are desirable.



Fig. 76.—Cowslip (parent).



Fig. 77.—Oxlip (hybrid).



Fig. 78.—Primrose (parent).

As examples of hybrid plants that occur both wild and also as raised by cross-fertilization in our gardens, we may instance the yellow Oxlip, which is not unfrequently found wherever the Primrose and the Cowslip grow near each other. A similar hybrid has long been known in gardens, where it sprang from a union of the coloured Cowslips and Primroses as fertilized by wind, or insects, or human agency. This cross is the origin of the coloured Oxlips known as Polyanthus-Primroses, and which differ but little from the wild Oxlip of the fields except in colour (figs. 76, 77, and 78).

Other examples are seen in the Star Narcissi (*N. incomparabilis* in variety), of which there are hundreds of forms originated by the fertilization of *Narcissus poeticus* with *N. Pseudo-Narcissus*. All the forms of *Narcissus odoratus* again are produced by the union of *N. Jonquilla* and *N. Pseudo-Narcissus*, and *N. Johnstonei* and its forms are similarly produced between *N. Pseudo-Narcissus* and *N. triandrus*.

Even amongst the tropical Orchids we find many wild hybrids, and *Phalænopsis intermedia*

(*Portei*), as imported from the Philippines, has been raised at Chelsea more recently by artificial fertilization, its parents being *P. amabilis* × *P. rosea*. As a broad rule, all hybrid plants possess a greater *vegetative* vigour than that of either parent.

In the crossing and hybridization of orchids the mode of procedure is different from that with other plants, for these flowers but rarely pollinate themselves, as the pollen is in solid, sticky, wax-like masses, and must perforce be carried mechanically from one flower to another. In the tropics of both hemispheres, where the finest of these flowers find a home, there are insects specially adapted to the task of fertilizing these flowers; but in our hot-houses, from which bees and flies are excluded, this insect-pollination cannot take place. This is one reason why orchid flowers remain fresh and fair for weeks or, in some cases, months after their flowers expand. These lovely blossoms go on waiting patiently for the marriage priest in the form of fly or bee—a priest that never, or but rarely, comes. If you closely examine the flower

of any large orchid, such as a *Cattleya*, *Lycaste*, or *Odontoglossum*, you will not see any anthers in the centre of the flower as in ordinary flowers. What you will find in the centre is a wax-like or fleshy column, above the lip, and at its apex you will see a little lid or cap, called the anther-case; and if you lift this cap off gently with a sharp-pointed pin or a knife you will observe the golden-yellow pollen masses ensconced underneath the cap, before it falls away.

Our sketch (fig. 79) shows the column of an orchid (*Cattleya*) enlarged—A is the column in

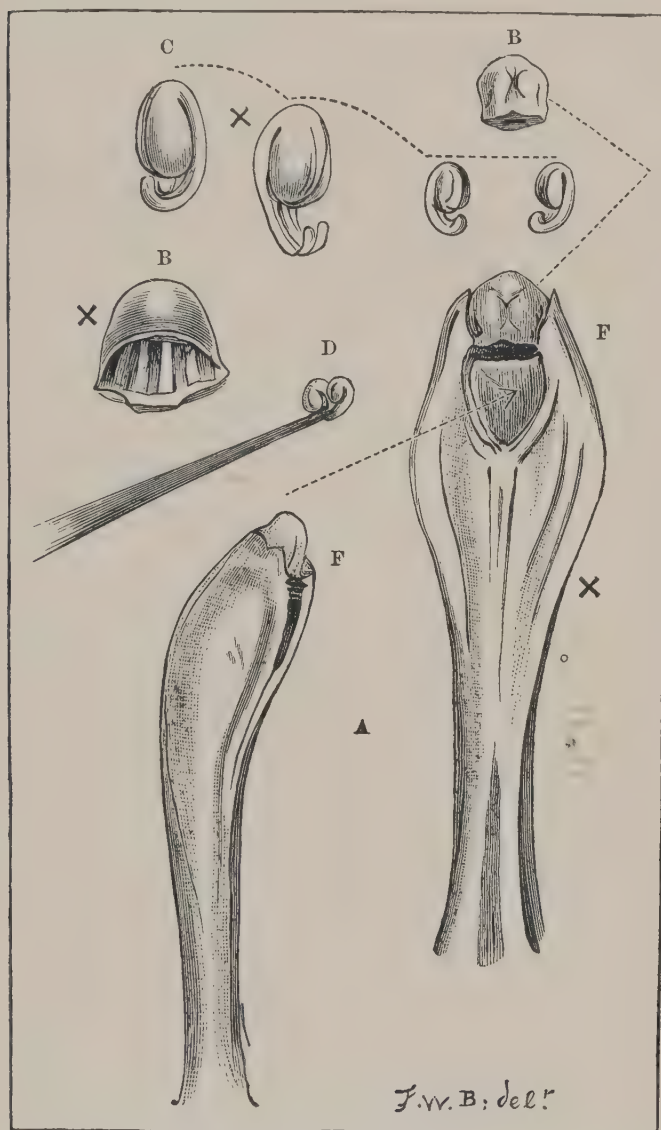


Fig. 79.—A, Front and side view of the column of *Cattleya* flower. B, Anther-cap, or pollen-case. C, Pollen-masses removed from anther-cap. D, Pollen-masses on tip of bamboo-pointer, ready for applying to the viscid stigmatic surface, as shown by dotted arrow. Figures marked thus X are slightly enlarged.

its entirety, B is the anther-cap at its apex; at C are the pollen-masses (to be removed on a toothpick), and at F you may see the stigmatic cavity or glutinous surface on which the pollen-masses must be placed in order to fertilize the young seeds (ovules) in the ovary or seed-vessel below.

In the case of *Cypripediums*, however, the case is a little different to the above general rule, there being two pollen-bearing regions, one on each side of the column behind the shield-shaped staminode in front; and the stigmatic

surface is the rounded back of the organ, below the column concealed from view by the heel of the slipper in these flowers. The pollen-masses are treacle-like, and stick readily to the stigmatic surface.

ISOLATION AND SELF-FERTILIZATION TO FIX VARIETIES.

We have seen that to effect change and improvement in cultivated plants, we employ cross-fertilization or hybridism, in addition to culture and selection, as the motor forces in order to obtain variations from existing and more or less unsatisfactory types. But having actually secured varieties of merit, we must face the difficulty of keeping them pure, either as individuals, or as races or strains. Individual varieties can frequently be increased or propagated by cuttings, or scions, or by other well-known vegetative means—such as offsets, stolons, runners, tubers, or layers. There are other cases, however, in which it is more convenient, or advisable, to perpetuate our choicest strains or races of plants by means of seeds. This is the case, for example, with *Cyclamen*, *Cineraria*, *Gloxinia*, *Calceolaria*, *Primroses*, *Stocks*, *Antirrhinums*, *Wallflowers*, *Begonias*, and other so-called “florists’ flowers”. Of these it is now possible to save seed that will very accurately “come true” in colour, shape, size, habit of growth, and other acquired characters.

How then, let us ask, have their satisfactory characters become so accurately fixed that they can be relied on to “come true” from seeds?

We have seen that the hybrid offspring of two species, or two different varieties, tends to be variable as raised from seed; but supposing that amongst the seedlings there is one that approaches our ideal, what shall we do in order to “fix” or render it stable? The answer lies in the one word—*isolation*. We must take every care that no foreign pollen obtains access to our plant, and if necessary,—and it is nearly always expedient or advisable,—we must carefully self-fertilize its flowers with its own pollen. It is in this way, by careful isolation and close in-and-in breeding (=self-fertilization), that all the self-coloured strains of “florists’ flowers” have been raised. With such crops as Cabbages or Turnips, and with Cucumbers and Melons, or Tomatoes, the greatest care has to be taken to keep the seeds of any particular varieties pure by rigidly isolating them from the effects of wind-borne or insect-carried pollen, and the careful selection, or the rigid weeding out of the bad forms known as “rogues”.

If the seeds of fruit-trees, such as Apples, Pears, Peaches, Apricots, or Plums, &c., be sown, and the young plants grown on to the fruiting stage, it is but rarely that they are like the parent tree that bore them. They may perchance be better, but as a broad rule are degenerate reversions from the seed parent. This may be, and often is, due to the flowers of the seed-parent having been fertilized by pollen from unsuitable or inferior varieties of the same tree. If it is wished to rear a seedling from the Ribston Pippin Apple, or Doyenne du Comice Pear, or the Victoria Plum, and it is desired that the seedling should resemble or be exactly like its parents, it is only a logical conclusion that pollen should be used from the same identical variety, and also precautions adopted against the occurrence of accidental cross-fertilization.

DOUBLE FLOWERS.

What are usually known as "double flowers" are those in which one or both of the essential whorls of the flower, that is to say, either the stamens, or the pistils, or both, are transformed into sepals or petals. It would be too much to say that "double flowers" are more beautiful than normal or "single" ones, but there is no gainsaying the fact that they are often more showy and more long-enduring than are the types from which they sprang, and so they lend themselves more conveniently to the practical requirements of the florist and decorator. Although "double flowers" are now and then met with in a state of wild nature, they are mainly due to the effects of cultivation. It is generally acknowledged that these monstrosities are the result indirectly of overfeeding. The overstimulation of the plant by a rich supply of food, destroys the natural balance that normally exists between vegetative growth and sexual vigour. Thus the petals are increased in size or in number, at the same time that the stamens or pistils are aborted and become petaloid. It seems a paradox to assert that overfeeding causes sexual sterility in plants, but it is well known to be a fact, and it is quite possible for the hybridist to rear double-flowered varieties and races of plants by turning this knowledge to advantage. In the case of Balsams (*Impatiens*) and Stocks (*Matthiola*), &c., the tendency to produce double flowers has not only been acquired by culture, but has become hereditary, and the same is true in the case of Roses, Hollyhocks, and other garden flowers. The first step in the rearing of double flowers, then, is overfeeding the seed-parent, so as to cause the production of

petals at the expense of stamens. At first only an odd stamen or two may be petaloid, and these only in one or two flowers; but this once observed, the battle may easily be won by carefully following up the advantage so gained. In plants that are constantly overfed such petaloid

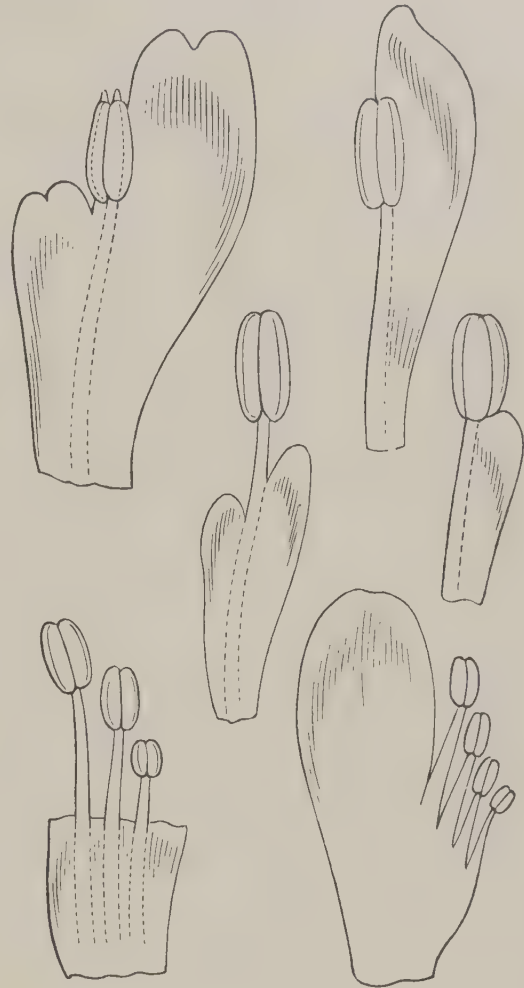


Fig. 80.—Petaloid Stamens of Camellia.

stamens may often be seen, as in Tulips, Azaleas, Single Camellias, and other flowers, especially so in those flowers having numerous stamens, as in Roses, Pæonies, Carnations, Malvas, Poppies, or Anemones. When petaloid stamens (fig. 80) are detected, the point is to use the pollen from these only,—on the stigma of the same flower,—or preferably of another flower having more than its normal number of petals on the same plant. This is the plan adopted by the Italian Camellia raisers, and also by the raisers of Double Azaleas in Belgium and elsewhere.

In some double flowers, such as Pinks and Carnations, Narcissi and Roses, it often happens that the duplication of petals is confined to the stamens, the styles or stigmas being normal and intact, and such flowers, if fertilized with pollen from the petaloid stamens of other flowers, often, indeed usually, produce seeds that yield double-flowered varieties.

If flowers become so perfectly double that all the stamens and stigmas are aborted, it follows that they cannot while in that state bear seeds,

the plethora induced by over-nutrition being too great, but by judiciously starving the plants producing such "perfect double" flowers, the sexual elements become strengthened, and semi-

double or almost perfectly single flowers result, which, when fertilized with pollen from petaloid stamens, yield seeds again capable of producing double-flowered plants.



Fig. 81.—Life-history of a Fern.

1 A Fern-prothallium seen from the under side. 2 An archegonium in longitudinal section. 3 An antheridium. 4 Escape of spermatozoids from antheridium. 5 Young sporophyte with first leaf arising from the prothallium. 6 Complete sporophyte of *Asplenium Ruta-muraria*. 7 Under surface of pinnule of same, showing linear sori and lateral indusium. 8 A young prothallium arising from a spore; the spore is below. 6 natural size; 1 $\times$ 8; 2, 3, 4 $\times$ 350; 5 $\times$ 6; 7 $\times$ 3; 8 $\times$ 240. (Kerner.)

CRYPTOGAMIC OR FLOWERLESS PLANTS, FERNS.

In the case of cryptogamic or flowerless plants, a kind of fertilization takes place, and it is quite possible to obtain what are analogous to cross breeds and hybrids amongst Ferns for example. These so-called flowerless plants are naturally increased by spores. Spores are asexual bodies, borne in little cases, that are arranged in clusters or lines on the backs of fern-fronds, &c., and take the place of seeds, though in structure and function they are really different things. The

spore-cases are hygrometrical, and burst open when the spores are fully developed; and these, being very small and light, are wafted about by the faintest breeze, and grow upon wet rocks, tree-trunks, walls, or soil, almost anywhere. No cotyledons, or seed-leaves, are produced as in seeds, but the spore merely throws out a dark-green flattish growth of cellular tissue, somewhat horseshoe-shaped, and called a prothallus or first expansion. Spores are merely vegetative bodies, and are not formed directly by the sexual union of male and female parents,

as in the case of seeds. Consequently the spores do not contain hereditary characters combined in their interior, as is the case with all seeds. But when the spore produces a prothallus, and it has attained to maturity, it bears on its under surface male organs called antheridia and female organs called archegonia, which in function at least are in a broad sense analogous to flowers.

From the antheridia male bodies called zoospores are liberated, spiral bodies furnished with eyelash-like cilia, which enable them to move rapidly over wet surfaces. The archegonia are small raised bosses or cones, hollow inside, and containing germ matter. There is a small pore-like opening, permeable to moisture, and into these openings the zoospores find their way, and so fertilization takes place, and the first young fronds of the fern appear. Whereas the fertilization of most flowering plants takes place most readily during dry and fine weather, the cryptogamic plants, on the other hand, can best be fertilized during damp or showery weather. Hence we find all fungoid pests, such as the Potato-disease, for example, increase most rapidly during warm wet weather, when the sperm matter or zoospores can travel most readily (fig. 81).

It is now apparent how fern hybrids or crosses may be produced now and then in the wild state, and of course much more freely in our ferneries, where many different kinds are grown in close proximity.

So far as is known, the spiral antherozoids or zoospores act perfectly automatically, running about wherever there is moisture, and so finding their way especially easy on the backs of the prothalli, where the moisture is always being condensed from the ground or wet surface upon which they grow. As these antherozoids run into any pore or crevice where there is moisture, or into any archegonia near to them, it is always possible that the antherozoids of one species may find their way into the archegonia of another kind; and in this manner it is possible for two kinds to be hybridized and for so-called fern hybrids to appear. Those who grow ferns apply this knowledge by sowing the spores of the kinds they wish to hybridize together in a seed-pan, or on any suitable moist surface; or the spores of many kinds are all mixed and sown together in the same receptacle, so that the chances of their prothalli becoming hybridized are multiplied indefinitely, as it were.

VEGETATIVE SPORTS OR BUD VARIATIONS.

Sports are those variations that take place apparently in a sudden and spontaneous manner,

and have long been a source of wonder and speculation to gardeners and others, and the exact cause of their simultaneous outburst still remains a mystery. Some botanists consider them due to the unequal divisions of the nucleus of the cell, while others look on all garden plants as being in a high state of tension, of which the balance is now and then disturbed by unknown causes, so that the variety slides back wholly, or in part, along its genealogical line. In this case "sports" may be due to "atavism", or the "throwing back" to ancestral forms.

"All the different branches, or even joints, of any plant are, in a very important sense, distinct individuals, since every one develops its own organs, each is capable of reproducing itself independently, and each is unlike every other because it is acted upon differently by environment and food-supply. It is not strange, therefore, that some of these individuals should now and then depart very widely from the ordinary type, and thereby attract the attention of a gardener who would forthwith take cuttings or grafts from the part. Every branch is a bud variety, just as truly as every seedling is a seed variety, and there should be no greater mystery connected with the sports of buds than there is with the variations from seeds, for the causes which produce the one may be, and are, equally competent to produce the other" (L. H. Bailey).

Sports are common in the case of plants that have been much cross-fertilized in the garden.

[F. W. B.]

CHAPTER X.

CLASSIFICATION.

SPECIES — GENERA — ORDERS — CLASSES — GENEALOGICAL
ARRANGEMENTS — ARTIFICIAL GROUPS.

In dealing with a large number of ideas, facts, or objects, some mode of classification becomes needful in order to facilitate research. There are two modes of classification, which may be broadly termed the *artificial* and the *natural* systems. In an artificial system the objects are arranged in any manner that may be convenient, without reference to the history, nature, or construction of the objects. An alphabetical index is an illustration of an artificial system of classification. The words in such an index are arranged in alphabetical sequence without the least reference to their significance. But if the words relating to gardening were all collected together under one heading, those relating to chemistry

under another, those pertaining to botany under yet another, the classification, if not perfectly natural, would at any rate be a nearer approach to a natural mode of grouping than is an alphabetical index. Again, if the words were all classed according to their relationships and derivation, we should have a natural system of classification. Botanists, except for mere purposes of reference, now universally endeavour to frame a natural method of classification. Owing, however, to our imperfect materials and to our inadequate knowledge, a perfect natural method does not exist, and is not likely to be framed, although every accession to knowledge contributes towards its improvement. An artificial classification is a purely arbitrary one; a natural classification is, or purports to be, a scheme representative of the genealogical descent of existing plants and of their relationship one to another, a pedigree, in fact, which circumstances prevent from ever being complete, but the imperfections of which are ever being lessened.

Thus, starting from an *individual* plant, let us say a White Lily, it is incontestable that that lily is the lineal descendant from two parent lilies like itself. We may ourselves have been witnesses of the fact. That these parents had a similar history is an inference only, but it is one that no one is likely to dispute. All these individual white lilies constitute a *species*. A species, then, is a collection of individual plants which we know, or which we have excellent grounds for inferring, have had a common origin. If we take for comparison with the White Lily, the Martagon or Turk's-cap Lily, we can trace a similar sequence, and we have no difficulty in assuming that all the Martagon Lilies have originated from one stock. It is also obvious that all the individual White Lilies differ from all the individual Martagon Lilies, so that we have now two groups of individuals—the one we call White Lilies, the other Martagon Lilies. In other words, the White Lilies constitute one species, the Martagons form another. Observe, we call them both “Lilies”, because, in spite of differences of appearance, they are still so much alike as to induce us to call them by the same name—Lily. In this way we get a notion of a *genus* as being a group of nearly-allied species, just as a species is a group of most nearly-allied individuals.

The genus *Lilium*, comprising the White Lily, the Martagon Lily, and very many others, is obviously like the Tulip. The Tulip genus, in its turn, comprises many species which differ

one from another as the species of lily do among themselves; and they differ so much from lilies as to justify the ascription of a different name, *Tulipa*. *Lilium* and *Tulipa* are thus two distinct genera. *Allium* and *Scilla* are other genera nearly allied to the two before named, and a vast number of others might be cited. A collection of such nearly related genera constitutes a *natural order* or *family*, in the case cited called *Liliaceæ*. Orders in their turn are grouped in higher divisions called *sub-classes*, these into higher and larger groups called *classes*, and so forth. The general principle upon which all these groups are founded is identical throughout, being dependent on the degree of likeness, and therefore of presumptive relationship, between the several members and groups.

No more common mistake is made in gardening books than that of the loose and inconsistent way in which the words variety, kind, species, tribe, family, and so on are employed. These words have in botany a definite significance, and to confuse them, as is generally done, is every whit as inconvenient as it would be to use with equal want of discrimination the words continents, islands, provinces, counties, cities, or other geographical expressions. Each of these has a definite meaning, and one cannot be correctly used as the substitute for another. So it is with botanical arrangements. It may therefore be convenient to insert in this place the principal groups in the order of sequence usually adopted.

INDIVIDUAL PLANT.

VARIETY.

SPECIES.

GENUS.

TRIBE.

ORDER OR FAMILY.

COHORT.

CLASS.

DIVISION.

Minor subdivisions are frequently employed, such as subspecies, sections, subgenera, subtribes, suborders, subclasses, &c., but these require no explanation. In the case of the lilies above mentioned, it may be said that they belong to the DIVISION Phanerogams or flowering plants; to the CLASS Monocotyledons, inclusive of all plants whose embryo has but a single cotyledon; to the COHORT Liliales; to the ORDER Liliaceæ; to the TRIBE Tulipeæ; to the GENUS *Lilium*; the two SPECIES mentioned being *Lilium candidum* and *Lilium Martagon*.

In practice it is in general only necessary to speak of the plant under its generic and under its specific name, thus, *Lilium candidum* or *Lilium*

Martagon. Each plant therefore has two names, one generic and one specific. The generic name is analogous to a family surname, the specific name corresponds to the baptismal name. The analogy is not perfect, for in the case of human beings we give a distinct name to each individual, whereas in plants we do not name individuals, but begin our nomenclature with the species. It is customary in botanical treatises to add to the name of the plant that of the author who described it, thus, *Lilium candidum*, Linn., indicating that it was Linnæus who described or classified the plant. In detailed monographs the work in which he described it, the page, the date of publication, would all be mentioned, together with any synonyms the plant may have; but these are only requisite in a monograph or book of reference.

When the same plant has, as often happens, been described under two names, the rule is to take the first correct name as the one to be adopted, and to consider all others as synonyms, to be disregarded in practice. For instance, what we know as the Martagon Lily was once considered (as by Ruppius and Salisbury) to represent a distinct genus, *i.e.* Martagon. By general consent, however, Martagon is not sufficiently distinct to merit a separate generic appellation; and therefore the adopted name is *Lilium Martagon*, Linn. The word being printed with an initial capital at once informs the botanist of the history of the plant. The principle of nomenclature is to accept as correct the name given by that botanist who was the first to assign a plant to its right genus. As Linnæus was the first systematically to adopt the binominal system of nomenclature, and thus introduce order into what was before confusion, so it is customary now to take the Linnæan nomenclature, dating from 1753, as the conventional starting-point, and to disregard any names that were applied before this date.

In the preceding paragraphs an epitome only of such portions of Botanical Science as are of most interest to the gardener is attempted. Those who desire to pursue the subject more fully are referred to the following standard books of reference:—

- A Student's Text-Book of Botany*, by Sydney H. Vines, D.Sc. Swan Sonnenschein & Co., London.
- A Popular Treatise on the Physiology of Plants for the Use of Gardeners*, by Dr. Paul Sorauer; translated by F. E. Weiss, B.Sc. Longmans & Co., London.
- The Treasury of Botany*, 2 vols.; for the uses of plants and descriptions of the more important genera. Longmans & Co., London.
- The Illustrated Dictionary of Gardening*. Edited by George Nicholson. L. Upcott Gill, London.
- Cultivated Plants, their Propagation and Improvement*, by F. W. Burbidge, M.A. W. Blackwood & Sons, London.

Of elementary introductions there is a vast number. Any of the following will be found very useful:—

- An Introduction to Structural Botany*, by Dr. H. Scott, Ph.D. Adam & Charles Black, London.
- The Elements of Botany*, by Francis Darwin. Cambridge University Press.
- An Elementary Text-Book of Agricultural Botany*, by M. C. Potter. Methuen & Co., London.

A complete list of all flowering plants, from the time of Linnæus to the year 1885, is given in the *Index Kewensis*, in four parts, and to which a Supplement, bringing the work down to 1895, is now in preparation. [M. T. M.]

CHAPTER XI.

INSECT AND OTHER PLANT ENEMIES.

BARK ENEMIES—BUD AND FLOWER ENEMIES—FRUIT AND SEED ENEMIES—LEAF ENEMIES—ROOT ENEMIES—STEM BORERS.

The subject of economic entomology is one of ever-increasing importance. The number of insects now known to be injurious to plants is very large, and their rapid increase is often alarming. Fortunately, however, the occurrence and depredations of many of them are local, though a few are wide-spread and common enemies.

This chapter deals with all the more important of those that infest gardens, orchards, fruit and plant houses. The descriptions of them, and the treatment recommended for their destruction or check, are necessarily brief. At the end of each chapter, treating of any particular class of flower, fruit, or vegetable, the insect or other pests that infest them are mentioned, and thus form a sort of key to this chapter. Should the insect be a scale upon the trunk or branches of the apple-tree, it will be found under "Bark Enemies". If it is devouring the leaves, or injuring them in any way, it will be found under "Leaf Enemies". On the other hand, should it be boring into the fruits of an Apple or Pear tree, making them what is termed worm-eaten, it will be found under "Fruit and Seed Enemies"; and so on, all being arranged in alphabetical sequence.

BARK ENEMIES.

American Blight (*Schizoneura lanigera*).—The wingless and viviparous females of this bark louse are fat, sluggish, reddish-brown, changing to a dull leaden colour, mealy on the back, and

furnished at the sides and tail-end with cottony hairs of increasing length. Winged forms, both males and egg-laying females, appear in July and August, but are more plentiful onwards to

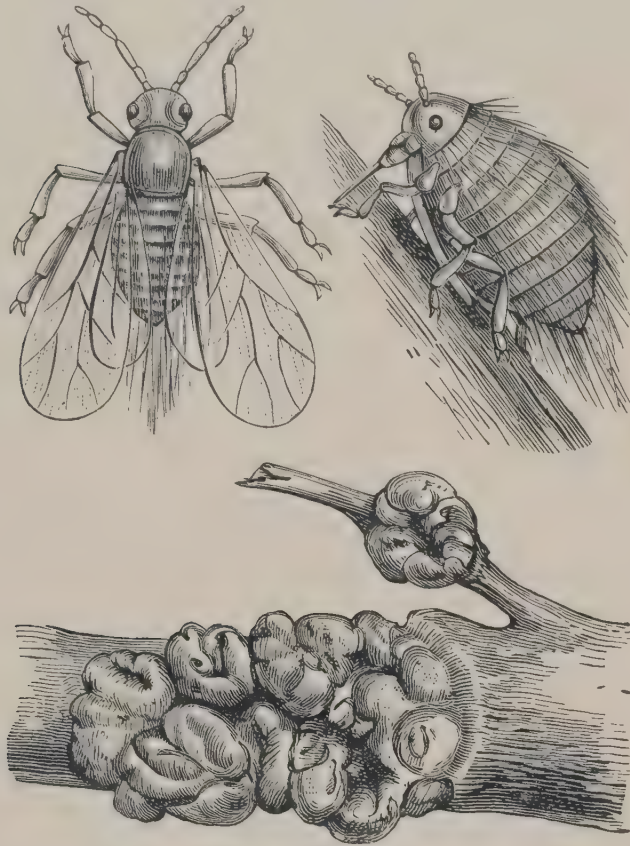


Fig. 82.—American Blight (*Schizoneura lanigera*).

October. The insect lives in colonies in the crevices of the bark and on the roots of Apple-trees, from whence it spreads to the young wood in summer, and sucking the juices with its pointed beak, causes the shoots to split open and to form cankerous-looking wounds, in which it lodges and increases the injury from year to year.

Remedies.—Avoid crowding the trees, and prune or thin them, preferably in autumn, when the fruit has been gathered, to promote clean, healthy growth. Clear away dead bark, moss, lichens, and whatever would afford shelter for the insects, and *burn* them. The first raid against the insects should be made in winter. The affected parts should be well rubbed with a half-worn brush, just kept moist with paraffin or some of its preparations, methylated spirits, fir-tree oil, Gishurst compound, or soft soap and sulphur. In the latter case the proportions are 1 lb. of soft soap to $\frac{1}{2}$ lb. of flour of sulphur in 7 gallons of water. A wash may be made by pouring 4 to 6 gallons of boiling water on 1 lb. of tobacco; after the mixture is cool, add 1 lb. of soft soap, and forcibly syringe the trees with it. Soap-suds, at the rate of 5 lbs. of soap to 20 up to 40 gallons of water, make another good wash. Syringe the trees with clean water next day. To clear the roots of American

Blight, remove the upper 6 inches or 8 inches of soil, well wash or scrub the larger roots with strong soap-suds, using plenty of the liquid to saturate the surrounding soil. Cover up the roots with fresh material taken from the middle of the rows.

Apple Mussel Scale (*Mytilaspis pomorum*).—The mussel-shaped scale is about $\frac{1}{8}$ inch long, pale-brown or gray, and, when numerous, is highly injurious to the health of the tree. The female insect under it has six legs, two antennæ, and two tail-like filaments at the end. The male scale is smaller, oblong, tapering to the head, but seldom seen. It gives rise to a minute fly with two long, delicate wings. The eggs are hatched about the end of May or the beginning of June, and the larva remains active only for a few days. It then settles down, inserts its beak in the bark, sucking the juices, and remains stationary for the rest of its life. The scale gradually forms over it, and by the middle of August the female louse is simply a bag of eggs, which are laid under the scale and remain there till spring.

Remedies.—The bark of the trunk and branches of the tree should be scraped in winter without injuring it, and then washed with some of the alkaline washes, such as concentrated lye of wood ashes or coarse potash, put on with a brush. A gallon of gas-water to 10 or 12 of water makes another suitable wash. The larvæ when newly hatched out are easily killed. With that object



Fig. 83.—Apple Mussel Scale (*Mytilaspis pomorum*).

in view, the trunk and branches of the trees affected may be brushed over at intervals of eight days about hatching-time with washes, consisting of a gill of kerosene in 5 gallons of water; of $\frac{1}{4}$ lb. of soft soap in a gallon of water; of 3 to 6 table-spoonfuls of phenyle to 4 gallons of water; or with soft soap reduced to the condition of thin paint, with a strong solution of washing-soda added to it.

Mealy-bug (*Dactylopius adonidum*).—When

full grown, the female insect is about $\frac{1}{8}$ inch long, white, tinted yellow, but wholly covered with a white mealy powder. It is oval in outline, fringed round the edges with bristles, and furnished with two longer filaments at the tail-end. The larvæ are more flattened, and vary in size according to age. The male is a minute, two-winged insect without a beak. The female is wingless, but capable of moving about all through life, and in this respect differs from the true scales to which it is related. The eggs are laid under the body previous to the death of the female. Mealy-bug is a pest of hothouses throughout the world.

Remedies.—Badly-infested plants may be destroyed unless very valuable. Soft-leaved plants may be sponged with a strong solution of soft soap, Gishurst compound, fir-tree oil, or an infusion of tobacco. Hard-leaved plants, like palms when mature, Gardenias and Stephanotis, may be syringed with a wine-glassful of paraffin in 3 gallons of water, kept well stirred all the time; wash with clean water immediately after. Tall climbers may be fumigated and forcibly syringed next morning with clean water. Kerosene emulsion is safer than paraffin. To 1 gallon of kerosene add $\frac{1}{2}$ gallon of cow's milk, and agitate the mixture till like thin butter; to a pint of this gradually add $1\frac{1}{2}$ gallon of water, stirring all the time. With this syringe the plants. Four ounces of carbolic acid to a gallon of water make a good wash for Mealy-bug on Vines, Gardenias, and other subjects.

Peach Scale (*Lecanium Persicæ*).—The fully-developed scale of the female is hemispherical, deep-brown, and shining, with a pale margin and stripe along the middle. Previous to this it is convex and oval in outline. As the insect beneath it attains maturity, and is filled with eggs, the legs disappear and the insect dies. The eggs remain under the scale till spring, when they hatch, and the larvæ roam over the tree, and, settling down, pierce the bark with their beak, and, while sucking the juices, remain fixed for life, as in the case of the Apple Mussel Scale. The male scale gives rise to a minute two-winged insect of a reddish-brown, with a black head, delicate wings, and two filaments at the tail.

Remedies.—When the trees are leafless in winter, scrub or wash the shoots with a stiff brush dipped in a strong solution of soft soap, or Gishurst compound, at the rate of 4 ozs. to a gallon of water, or fir-tree oil. In careful hands paraffin may be used with which to wet the brush; but on no account should the buds be touched with it. Kerosene emulsion is a

safer remedy than paraffin. (For its preparation see under Mealy-bug, described above.) Painting the shoots with mixtures of clay, cow dung, soot, sulphur, and lime, after washing, is a proceeding of doubtful advantage. The walls and wood-work of the house should, however, be washed with carbolic soap.

Pear Oyster Scale (*Diaspis ostreæformis*).—The fully-developed scale of this insect is very small, circular in outline, more or less wrinkled all over, slightly elevated in the centre, much resembling an oyster-shell in miniature, pale-brown or gray, with a yellowish spot in the centre, and slightly indented at the margin. The female insect under this is wingless, legless, some-



Fig. 84.—Pear Oyster Scale (*Diaspis ostreæformis*).

what heart-shaped, thinly hairy, and yellowish-white. She dies under the scale when her eggs are fully developed. The male is very minute, with six hairy legs and antennæ, two delicate wings, and a pale ochreous body suddenly prolonged into a tail-like point. The scales are scattered or more or less densely clustered over the bark of Pear-trees. The life-history of the creature is very similar to that of the Apple Mussel Scale as described above, and to which it is closely allied.

Remedies.—Infested trees may be cleaned precisely as in the case of the Apple Mussel Scale. Some authorities recommend syringing the trees, when they are leafless, with a solution of soft soap and hot water.

Pear-sucker (*Psylla Pyri*).—In the perfect form this jumping plant-louse resembles the frog-hopper in shape, and belongs to the same family, but is very much smaller, four-winged, and pale-green at first, changing to various shades of red, crimson, or black. The wings are pure white, the head large, the eyes red, and the an-

tennæ are curious in having two bristles at the apex. The larva is yellow, but the pupa stage is more dusky, with dark wing-cases. As the Pear-trees commence to flower in spring, the male and female insects leave their hiding-places, and, after pairing, the female lays her eggs on the young shoots or under side of the leaves. The larvæ hatch out in ten days or a fortnight,



Fig. 55.—Pear-sucker (*Psylla Pyri*).
Magnified.

and commence sucking the juices of the plant about the axils of the leaves, where they are covered with a copious exudation of sap. In the pupa stage they distribute themselves over the young shoots, doing great damage. During both these stages they are very destructive to the health and vigour of badly-infested trees, causing the leaves to droop, owing to the great loss of sap, which drops on the foliage beneath and on the ground. Ants and other insects are attracted by the gummy, sweet exudation, and thus call attention to the enemy. When full-fed the pupa fixes itself to a leaf, and, splitting the pupa-case, emerges in the perfect condition.

Remedies.—Trees that are attacked by this insect in summer should have the rough bark well scraped off to lessen the number of hiding-places of the insect. When the larvæ and pupæ are busy at work in early summer the trees should be thoroughly syringed with soft soap and water at the rate of 1 lb. of the former to 8 gallons of water, to which some tobacco-water has been added. The experiment may be repeated if not completely effective at first. Gishurst compound may replace the soap. Soft soap, mixed with a strong solution of washing-soda, may be used as a paint in winter.

Rabbits and Hares.—Great damage is often done by these animals barking the stems of many kinds of trees during winter, especially when there is snow on the ground. Valuable trees, or those in prominent positions near the mansion, should be protected by a guard of galvanized wire-netting about 2½ feet high. In other cases bundles of dead wood, such as the prunings of hedges or gorse, may be tied round the base of the trunk. Various expedients have been tried, by painting the base of the trunk with something disagreeable to the animals, and with varying success. Train-oil mixed with cart-grease and soot till it forms a paint has been employed, and found successful. Another receipt

is to mix equal parts of soft soap, flour, and sifted ashes, putting on a layer ¼ inch thick. Other experimenters paint the trees with slaked lime, train-oil, dog's dung, grease, and blood obtained from the slaughter-house, cow's urine, or rub the stems with the rind of smoked bacon.

Vine Scale (*Pulvinaria Vitis*).—The female scale is oval in outline, deeply notched at one end, elevated along the centre, and brown, with some transverse lines near the middle. From the notched end a cottony material begins to protrude, and increases in size till three or four times as large as the scale itself. Underneath it is a mass of eggs, and soon after the small, yellowish-white lice hatch out and commence to ramble all over the stems, and even the leaves and berries of the Vine, doing great mischief if left undisturbed. They settle down, insert their beak in the bark, and suck the juices, meanwhile going through the same stages of growth as their parent did.

Remedies.—Being of large size and easily seen, the scales can readily be scraped off with a knife and destroyed. This should be done before the insects get numerous, and before the eggs have time to become hatched.

Wæberian Tortrix (*Samolisa Wæberiana*).—This small moth is only ½ inch to ¾ inch in expanse. The fore-wings are brown, variegated

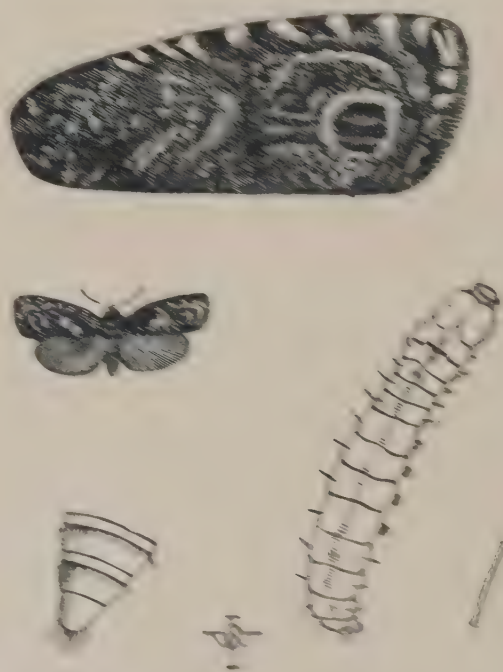


Fig. 56.—Wæberian Tortrix (*Samolisa Wæberiana*).

with irregular orange streaks and some branching silvery ones. The hind-wings are mostly brownish-black, and all are fringed at the outer end. The larva or caterpillar is ½ inch to ¾ inch long, whitish, with a pale-brown head and a pinkish line along the back. It penetrates the bark of most fruit trees till it reaches the

inner bark and cambium layer, where it finds a rich store of food. When a tree is once attacked, repeated generations are bred there, and may be found at all seasons of the year. Great cankerous wounds are produced in time, rendering the trees unhealthy and liable to be snapped across by the wind.

Remedies.—Badly-infested trees, unless very valuable, should be cut down and burned. In the case of smooth-barked young trees, the caterpillars may be destroyed by pushing a wire into their burrows. Where only small patches of the bark are infested, these may be shaved off with some sharp instrument, without injuring the inner bark if possible, and the materials burned. Where the bark has been removed are favourite places for the moth to lay fresh batches of eggs, and to prevent this the trunk and larger branches should be syringed several times during summer with strong soap-suds, Gishurst compound, or painted over with soft soap to which some washing-soda has been added, and diluted to a thin paint with water.

BUD AND FLOWER ENEMIES.

Apple-blossom Weevil (*Anthonomus pomorum*).—The weevil is $1\frac{1}{2}$ to 2 lines long, with a long slender beak, and has a pitchy-brown body covered with short gray hairs. The wing-cases are rusty-red with a black margin, and

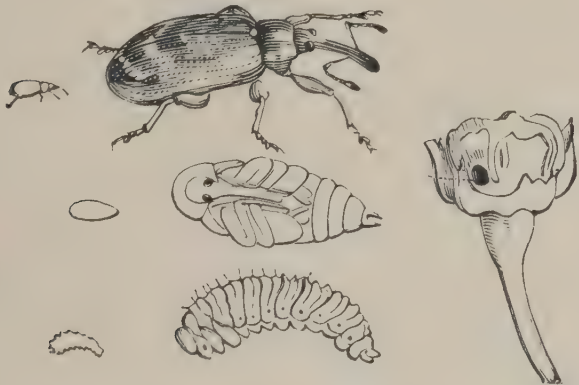


Fig. 87.—Apple-blossom Weevil (*Anthonomus pomorum*).

are covered with whitish hairs; the legs and antennæ are also rusty-red. When the flower-buds of the Apple are fairly well developed in spring, the female weevil busies herself laying a single egg in each. Egg-laying continues till the blossom expands, but not later, and the eggs hatch in about six days, and the weevil passes through all its stages in a month. The grub is white with a black head, legless, and feeds upon the stamens and ovary, while the petals wither and never open.

Remedies.—Clean culture is a primary requisite as a means of prevention; the removal of

all rubbish from the ground, as well as moss and rough bark from the trunk, prevents the weevils from finding secure hiding-places in winter. As the females generally crawl up the trunks and seldom resort to flying, many of them may be intercepted on their way up by tying strips of brown paper or tarpaulin thickly smeared with cart-grease round the stem of the trees about the end of March and onwards. During April, and especially on fine days, when the eggs are being laid, cloths may be spread under trees that are known to be affected; then by tapping the trees or shaking the branches the alarmed weevils drop on to the cloths and may be destroyed. All unopened and withered blossoms should be collected and burned before the grubs hatch out.

Carrot-blossom Moth (*Depressaria Pastinacella*).—The perfect insect is a small creature somewhat like a clothes-moth, and slightly under an inch in the expanse of its wings, the fore ones of which are ashy-gray with white specks and a few brown streaks. The caterpillar is greenish-gray, $\frac{1}{2}$ inch long, and may be found in the umbels of flowers of Carrots and Parsnips during July and August. It draws the umbel together with threads and consumes both flowers and young seeds at its leisure. It is therefore only harmful to a seed-crop.

Remedies.—The wriggling caterpillars are very active and drop down when disturbed. They may therefore be collected in sieves covered with paper or a white cloth, or, what is more certain, tarred trays may be carried along the lines of flowering plants and the umbels of blossom shaken over them. The plants might also be dusted with hellebore powder while yet wet with dew, or they might be syringed and then dusted.

Cockroaches.—The common Cockroach (*Blatta orientalis*) is a large insect, active all through life, and in the larval stage varies from a pale to a deep reddish-brown, while the adult appears almost black. The females have rudimentary wings only, but the males, when fully grown, have large wings, the front pair of which are brown and horny, covering the folded and membranous hinder ones when at rest. The antennæ or horns are generally longer than the body, but the wing-covers and wings are shorter. The American Cockroach (*Blatta* or *Periplaneta americana*) is a much larger insect, about $1\frac{1}{2}$ inch long and $\frac{1}{2}$ inch wide. It is brown or grayish-brown, and the wing-covers and wings are longer than the body in both sexes. The horns of the male are 2 inches long. The

larvæ are active like the adults, but wingless. The American Cockroach is generally more common in hothouses than the common one, and is much more destructive to the flowers and scapes of Orchids, as well as to the flowers and leaves of stove-plants generally at all seasons of the year.

Remedies.—Cement all holes and crevices in walls, as well as lessen the number of hiding-places wherever possible in the plant-houses. Poisoning is a sure and effective remedy, and may be effected by placing bits of phosphorus paste on pieces of slate, tile, or broken pots, and laying the same in their runs about the houses. This may be done before leaving off work at night, then the pieces collected in the morning and stored in a safe place out of the way till night. Boiled potatoes, sweetened dough, or roasted apples poisoned with arsenic may be used instead, except in or near fruit-houses, where arsenic would be dangerous if carried about by the insects. Beetle-traps baited with something sweet might be employed in such cases. Deep jars sunk in the ground and partly filled with much-diluted strong-smelling molasses will betray and drown hundreds of them.

Currant Gall Mite (*Phytoptus Ribis*).—The body of this mite is oblong, slightly narrowed to a point at the tail end, which terminates in a pair of bristles. It is very sluggish, dirty-white, furnished with four short legs near the head, and a short beak with which it sucks the juices of the leaves of the Black Currant while still in bud. As the buds of the Currant swell in autumn and all through the winter and spring, those that are affected with the mite may be recognized by their large size and globular shape. Mites may be found in hundreds in such buds, and to the naked eye appear like white dust. They remove to the new buds as they develop towards the end of the season.

Remedies.—Some varieties, and certainly some bushes of Black Currant, get more affected than others even on the same piece of ground. When the swollen buds are few, they should be picked off and burnt; badly-affected branches may be cut off, or the bush itself may be grubbed up and burnt. Sometimes it is necessary to grub up a whole plantation and make a new one at some distance off. Clean culture and the avoidance of crowding should at all times be observed, and the first swollen buds that appear should be promptly removed and burnt, to prevent the mite from increasing.

Earwigs (*Forficula auricularia*).—When full grown, earwigs are more or less of a dark-chestnut except after casting their old skin, when they are pale, as are the larvæ or young. When numerous they are very destructive to vegetation, but particularly to flowers and fruit, on which they feed at night, hiding themselves very cunningly during daylight. They are not exclusively vegetable feeders, but will devour aphides, thrips, wild bees, and even their own species when hard pressed for food or confined together. The female broods over her

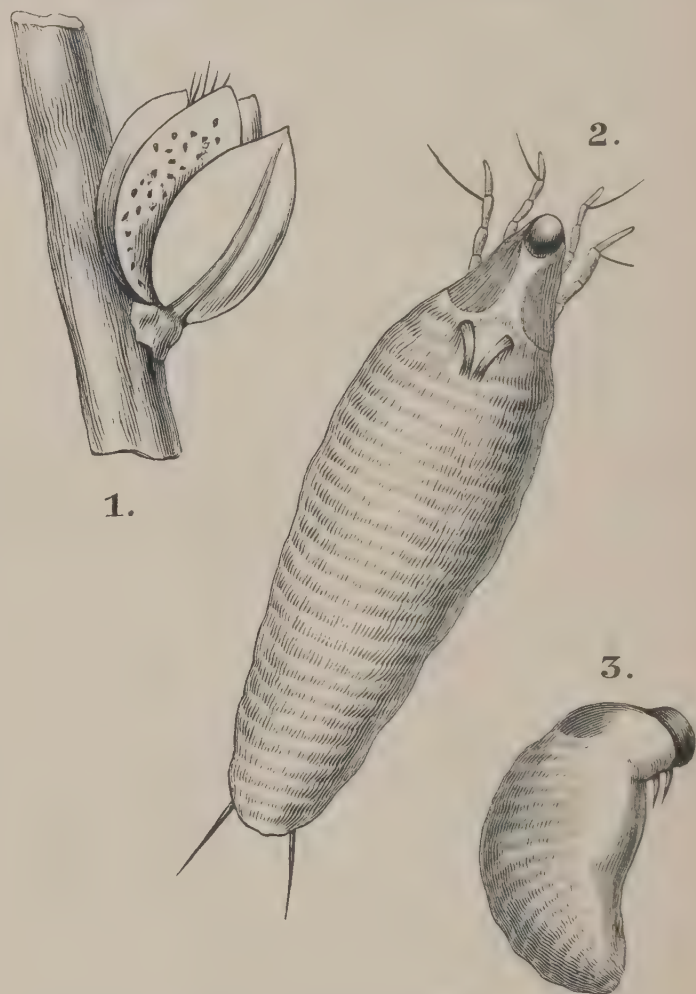


Fig. 88.—Currant Bud Disease.
1. Infested bud; 2. Mite (*Phytoptus Ribis*); 3. Same, younger.
(All greatly magnified.)

eggs and young like a hen, but the progeny will even devour her, at least if she should happen to die. When full grown they have perfectly-developed wings neatly folded under the small wing-cases and are believed to fly chiefly by moonlight, so that they may come from a distance to gardens.

Remedies.—The old practice of placing bean-stalks or something hollow in the neighbourhood of their haunts is well known. The bean-stalk should be examined every morning and the earwigs blown out and destroyed. A better and more expeditious plan is to put a tuft of dry moss loosely in the bottom of small pots to be placed on the top of stakes supporting the plants or otherwise. Examine these every morning. The Fetid Rove-beetle or Devil's

Coach-horse is an inveterate enemy of the earwig, destroying large numbers of them, and should be encouraged.

Raspberry Beetle (*Byturus tomentosus*).—

This is a small oblong beetle about $1\frac{1}{2}$ to $1\frac{3}{4}$ line long. The body is reddish-brown with a pitchy head and shoulders, but the whole is more or less covered with a yellowish-gray down. When the Raspberry is in bloom the flowers are infested by the beetles, which have then reached the perfect state. The females lay their eggs by the side of the young fruit, and the larvæ soon after penetrate this, feeding upon it, and reaching their full size by the time the fruit is ripe. The grubs are then dirty-white, with a brown head and six legs, and, leaving the fruit, form a cocoon in some crevice of the stem or other shelter, where they pass the winter, and, reaching the perfect state, attack the flowers in spring.

Remedies.—A most effective plan of destroying this beetle would be to collect all the fruits that contain a maggot and burn or bury them deeply. The process would be a tedious one, nor can the affected fruits always be determined without pulling them off. A more practical method would be to use tarred trays, boxes, or old sacks, into which the beetles could be shaken in the early morning while sluggish; during the day they fly away when disturbed.

The fore-wings are shining-brown with four yellow spots near the anterior margin, and two larger ones near the hinder margin. The caterpillars are red with a black head, and $\frac{1}{4}$ inch long.

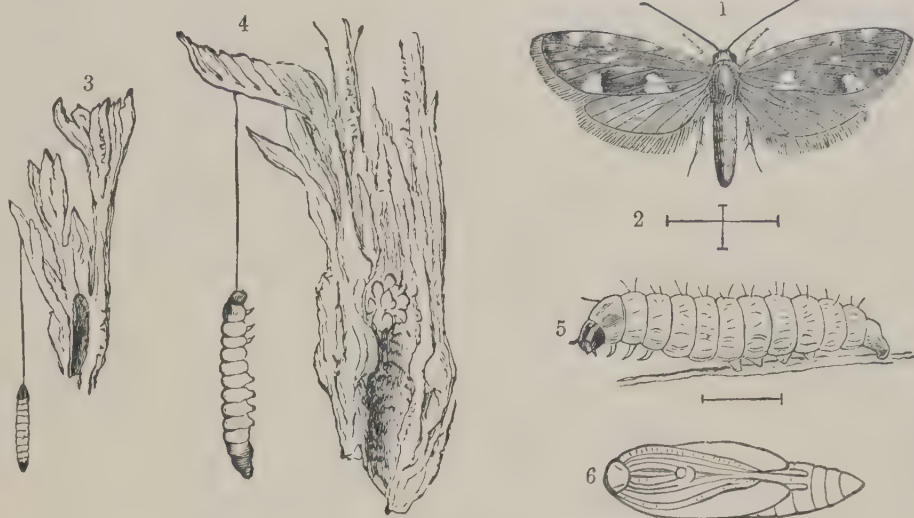


Fig. 90.—Red-bud Caterpillar (*Lampronia Rubiella*).

1. Moth (magnified); 2, natural size. 3. Caterpillar (natural size). 4. Caterpillar (enlarged). 5. Caterpillar (greatly magnified and natural size). 6. Chrysalis (greatly magnified).

They live through the winter and enter the leaf-buds, gnawing their way downwards into the pith of the shoot, which ultimately withers, if not already destroyed in the bud stage. When the caterpillar passes through the pupa to the perfect state, the females lay their eggs in the fully open flower, and the caterpillars live in the white core of the fruit till the latter is ripe, and, leaving this, hibernate till spring, when they penetrate the leaf-buds as their parents did the year before.

Remedies.—The most certain plan of checking the ravages of this insect is to cut off the tips of the shoots as soon as they show clear evidence of the caterpillars at work inside them, dropping them into close baskets as the work proceeds. At short intervals the baskets should be emptied on to a fire kindled for the purpose, or into the furnace of a hothouse boiler.

Yellow Aphis (*Siphonophora lutea*).—

The larvæ and wingless females vary from greenish-yellow to clear shining-yellow, and the latter have a brown or black patch on the back. The winged females are greenish-yellow with long wings. It infests the flowers of Orchids at all seasons. In company with it another species may often be found, namely *S. circumflexa*, which

varies from pale-green to yellow. The wingless females have a horse-shoe shaped black blotch on the back and the winged females have a triangular olive or black blotch on the back, or this may be broken up into four blotches of different sizes.



Fig. 89.—Raspberry Beetle (*Byturus tomentosus*).

1, 2. Raspberry Beetles (magnified). 3. Natural size. 4. Maggot (magnified). 5. Natural length. 6. Infested Raspberry fruit.

They may also be attacked in the pupa state by cutting away all the old canes after the fruit has been gathered, and burning them at once. In like manner clear away all other rubbish.

Red-bud Caterpillar (*Lampronia Rubiella*).

—The moth is slightly under $\frac{1}{2}$ inch in expanse.

Remedies.—Fumigation with tobacco-paper, tobacco, MacDougal's fumigating sheets, the Thanatophore or Lethorion vapour cone, or XLALL Vaporiser, should be resorted to on still nights. This should be done at the commencement of the evil before the aphides have had time to spoil the flowers. Choice flowers may be cleaned by means of a camel-hair pencil. Fumigation should be done lightly.

FRUIT AND SEED ENEMIES.

Ants.—There are about 30 species of ants in this country, besides which our hothouses are infested with numerous exotic species. Out of doors some of them prove very annoying on lawns by casting up heaps of rubbish where they make their nests, by undermining and cutting the roots of choice plants in the border and rockery, and by destroying the fruit of Peaches, Nectarines, Pears, and other soft fruits. Under glass they render various plants filthy by farming aphides and scales, by undermining the roots of pot-plants, and by eating soft fruits.

Remedies.—In Melon, Peach, and other fruit-houses, deep jars, partly filled with water in which brown sugar or strong-smelling molasses have been dissolved, should be sunk to the rim in soil near their runs, or have bridges placed against them, and ants will be decoyed and drowned in large numbers. Bones with a small quantity of boiled meat upon them will attract ants in large numbers, when the bones now and again may be dipped in boiling water to kill the vermin. Pots or seed-pans filled with dry earth may be stood near their runs, and the ants will often make their nests in them, when they can be carried to a distance, emptied, and the ants completely destroyed. Indoors or outside, where there are no valuable plants to be destroyed, the nests and runs should be sprinkled at intervals with water and kerosene at the rate of 6 gallons of the former to 1 of the latter. Water with a twelfth of its bulk of carbolic acid may be used in the same way. Lime that has become broken down by exposure to the air may be scattered freely about their runs and nests in dry places and in dry weather. Nests in grass may be dug up and exposed in frosty weather, preferably about mid-winter, for the sake of the grass.

Apple Sawfly (*Hoplocampa testudinea*).—The perfect insect is a four-winged fly about $3\frac{1}{4}$ lines long, and reddish-yellow, with the top of the head, back of the shoulders, and abdomen black. The wings are transparent, with the base of the

nerves blackish. The female lays an egg in each flower of the Apple in May, and the white or pale-yellow grub penetrates the interior of the fruit, upon which it lives till the end of June or the beginning of July, by which time the fruit is as large as a walnut and drops. The grub then leaves it and pupates in the ground till the following spring.

Remedies.—As in the case of the Codlin Grub, all fallen fruits should be promptly collected and burned, fed to pigs, or deeply buried in soil before the grubs have time to leave them. Quicklime scattered over the ground beneath badly-infested trees would doubtless destroy many of the grubs escaping from the fruit. A more certain remedy would be to skim off the surface soil beneath the trees to the depth of some inches, and bury it deeply in trenches between the rows of trees, dressing it heavily with gas-lime at the same time.

Bean Beetles (*Bruchus granarius* and *B. flavimanus*).—The first-named is the most common, and is less than 2 lines in length, black,

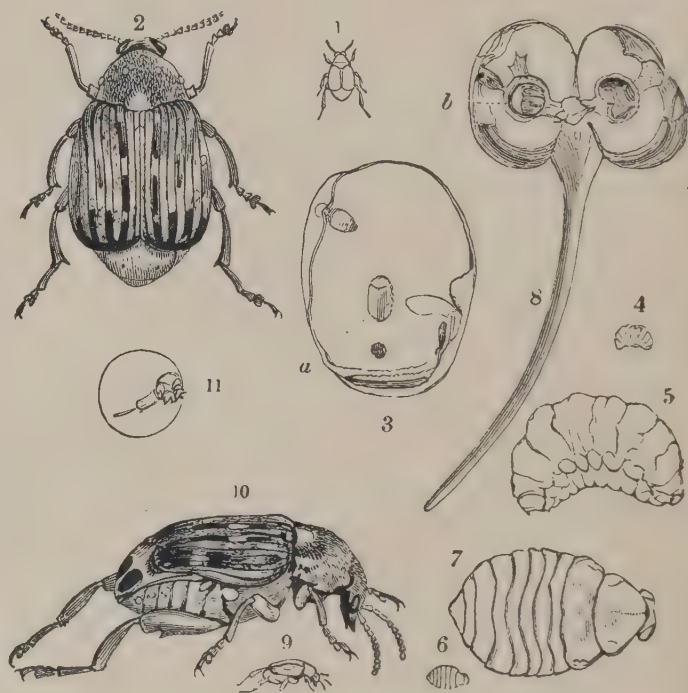


Fig. 91.—Bean Beetles.

1. *Bruchus granarius* (natural size). 2. Magnified. 3. Section of infested bean. 4. Maggot (natural size). 5. Enlarged. 6. Pupa (natural size). 7. Enlarged. 8. Infested bean germinating. 9. *Bruchus flavimanus* (natural size). 10. Enlarged. 11. Infested pea. 4, 5, 6, 7, are common to both species.

and covered with short, brown hairs. The wing-cases have spots of whitish hairs. The first pair of legs are rusty, the rest black. *B. flavimanus* is black, but the head and shoulders are clothed with orange hairs, and the wing-cases with grayish-white hairs. The front legs are bright rusty red, and the others yellowish. The old beetles get bare and nearly black. From May and June till August the females busy themselves laying eggs on the pods of Peas,

Long-pod, and Broad Beans. The larvæ penetrate the pods, and then the seeds, in which they develop into fat, white, legless maggots. They generally remain in the seeds, and, getting sown, they hatch out to renew the evil.

Remedies.—The grubs continue to feed in the seeds after they are gathered, until, when full fed, they have eaten close to the skin of the Pea or Bean. Their presence may be detected by a small and paler spot than the rest of the seed. If on examination a grub is found within, such seed should not be sown till April. By that time the beetles will have left the seed or died in them, and the opening from whence they came out is easily detected. On a small scale all such seeds should be rejected, as they cannot give rise to strong healthy plants. The best remedy, however, is to immerse the seeds in boiling water for one minute, but not longer, when intended for sowing. This should be done as soon as the seed is gathered and the grub is not yet fully grown.

Birds.—Most birds are really friends in disguise on account of the large numbers of slugs, caterpillars, grubs, and insects generally which they destroy, even if they claim a tithe of various fruits, seeds, and young vegetables. Raspberries, Cherries, Strawberries, as well as Gooseberries and Currants, which it is intended to preserve as long as possible, should be protected with old herring netting, which is cheap and easily procurable. Apples and Pears are seldom attacked by blackbirds and thrushes till they are fit to gather. Valuable early crops on walls could readily be netted. More damage has been done to Raspberry canes by shooting at the birds than the latter themselves do to that crop. The canes get riddled with the shot and cannot bear so well next year. It may be necessary, where wood-pigeons are troublesome to Gooseberries and young vegetables, to shoot them. Staking Peas will often stop the depredations of those birds. The titmouse is often more blamed than guilty, for it is considered to be after the “worm i’ the bud”, rather than anything else. Bullfinches, where numerous, are very destructive to the buds of Apple-trees in winter and spring, and their numbers might be reduced by shooting; but some of the many means of driving them away should be attempted in the first place. The sparrows, or “Avian Rat”, is the most troublesome and mischievous of all British birds, whether in the corn or seed-fields, or gardens. Where much Ivy abounds, this should be regularly cut in with the shears every spring, whether on houses, walls, or trees, so as

to reduce the shelter for sparrows. Their nests may also be pulled down if they cannot be held in check by other means. Crocuses, Carnations, Primroses, and other garden flowers, as well as Lettuces, may have black threads stretched amongst them. Currant and Gooseberry bushes, and even Peas, may be threaded, and seed-beds netted. In the case of orchards and large quantities of valuable seed cultures, a boy may be engaged to scare away birds. Scarecrows are generally so evidently a burlesque on anything real that birds take pleasure in sitting upon them. Small windmills, with rattles upon them, are often very effective; pieces of glass may be hung up in such a way that they will swing and scintillate with the sunlight, and even rattle if two pieces are tied in proximity. Feathers stuck in a piece of cork, with a cord passing through the latter, and hung between two stakes, and similar devices, often answer very well in alarming and driving away birds. Incessant war should be waged against the sparrow, the worst of all feathered pests.

Carrot-seed Moth (*Depressaria depressella*).

—The male of this moth is only $\frac{1}{2}$ inch in expanse, while the female is about $\frac{3}{4}$ inch, and in both cases the wings are of a silky-brown, or the fore ones are inclined to chestnut. The caterpillar is brownish-gray, with small black spines ending in hairs, and may be found devouring the flowers and seeds of Carrots and Parsnips in July and August.

Remedies.—The caterpillars are very lively, and let themselves down with a thread when alarmed. Advantage may be taken of this by passing along the rows of flowering and fruiting plants with tarred boards or trays, and bending the stems over the trays so that the caterpillars may fall upon the tar. Parsnips are preferred to Carrots, so that a crop of the latter may be saved by planting a row of Parsnips to every two beds of Carrots; then the Parsnips may be cut into close baskets or boxes and immediately burnt, to destroy either caterpillars or pupa.

Codlin Grub (*Carpocapsa Pomonella*).—This little but destructive moth is about $\frac{3}{4}$ inch in expanse. The fore-wings are gray, with dark lines crossing them, and have an eye-spot towards the apex, surrounded by a coppery band. The caterpillar is pink, with a brown spot on the neck, and is all too frequent in Apples, and less often in Pears, during August and September. The moths precede them in June and July, and the female lays a single egg, generally in the eye of the fruit, and the caterpillar when hatched out penetrates the fruit, ultimately often causing

it to fall. When full fed it lays up in crevices of the bark and other shelter for the winter, assuming the pupa state.

Remedies.—Collect all fallen and grub-eaten

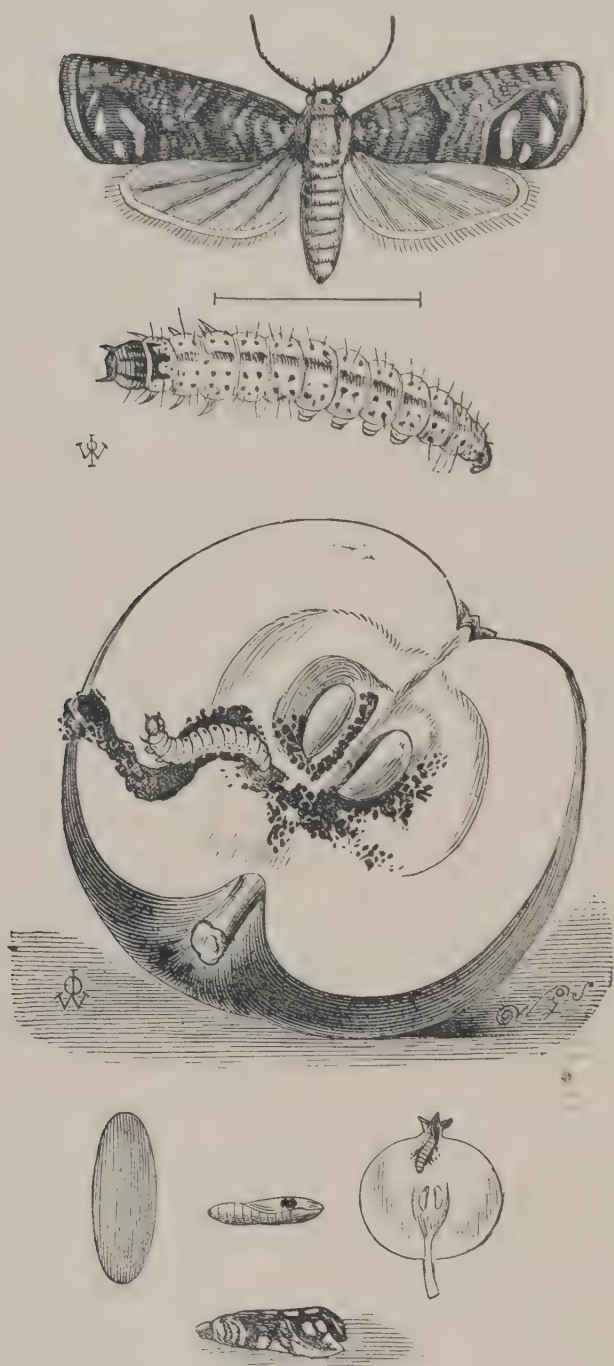


Fig. 92.—Codlin Grub and Moth (*Carpocapsa Pomonella*).

fruit and burn it, or feed pigs with it as soon as it falls. Strips of cloth or sacking may be tied round the trunk of the trees near the base, and the caterpillars will lay up for the winter underneath the bands. Commence in July and continue for a week after the fruit is gathered, examining the bands every ten days or so, and destroying caterpillars or pupæ. Codlin-grub traps, consisting of several pieces of wood fastened together by a screw in the centre and held apart with thin laths, may be hung against the trees and examined periodically as in the other case. Paris-green and London-purple are often employed with great success against the Codlin Grub. One pound of either should be well mixed in 200 to 250 gallons of water,

thoroughly stirred, and then applied to the trees as soon as the blossoms fall, in the form of a fine spray, till the leaves and fruits are just moist, but not dripping. The operation may be repeated when the fruits begin to swell. Both ingredients are highly poisonous, and should be used with care; they get washed off by rain long before the fruit is ripe. Properly constructed spraying-machines of different sizes are readily obtainable, and should alone be used. Sulphate of copper at the rate of 1 lb. to 160 gallons of water may be employed in the same way as Paris-green.

Earwigs.—These are very destructive to Peaches, Nectarines, and other soft fruits. For remedies see under BUDS AND FLOWERS.

Grape Moth (*Ditula angustiorana*).—When the wings are expanded, this moth only measures $\frac{1}{2}$ inch to $\frac{3}{4}$ inch. The fore-wings of the male are grayish-yellow, with various brown markings. Those of the female are more of a reddish-yellow hue, with reddish-brown markings. The caterpillar is of a dirty greenish-gray, with a pale-buff shining head. It is found on most trees, tying together and devouring the leaves, but for some years past has proved injurious to ripe grapes by tying them together and piercing

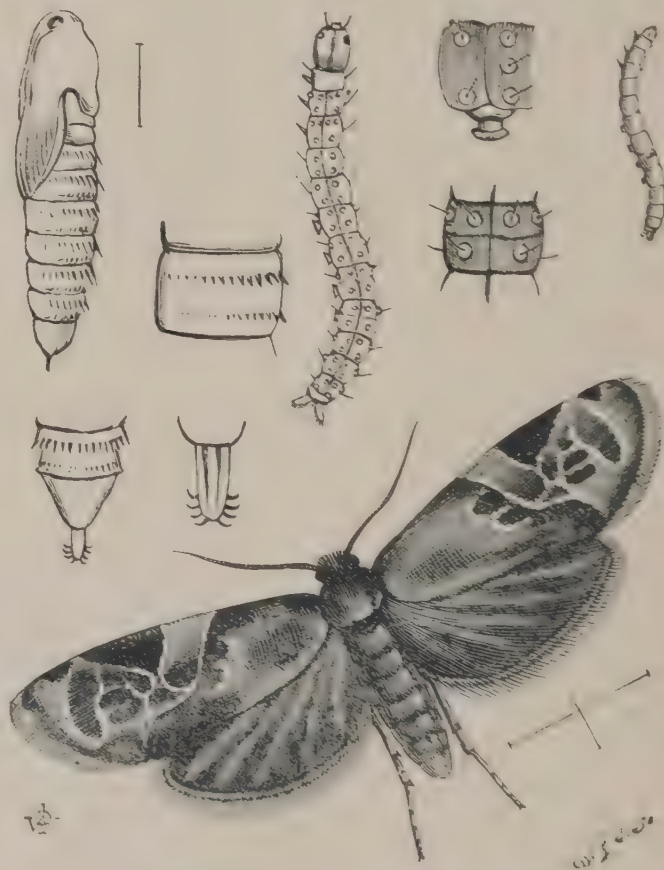


Fig. 93.—Grape Moth (*Ditula angustiorana*).

for a short way into the pulp, causing several berries to decay.

Remedy.—Like the larvæ of many other moths, the caterpillar in this case suddenly lets itself down with a thread when alarmed. Ad-

vantage may be taken of this by holding a box covered with tissue-paper, or a tarred tray, beneath the bunches of grapes, which should be gently shaken to cause the caterpillars to drop, when they may easily be destroyed.

Lettuce Fly (*Anthomyia Lactuæ*).—The males of this fly are black and bristly all over the body and legs; the abdomen, however, is gray, with a black blotch. The females are much lighter in hue, with a chestnut band on the face. The grubs are dirty-white, legless, cut short at the tail-end, and toothed there. The perfect flies appear in April, May, and June, and the females lay their eggs on the flowers of the Lettuce. The grubs hatch out and feed upon the seed during August and September; they change to the pupa state and hibernate in the Lettuce heads or in the ground till April again.

Remedies.—Those who grow Lettuces for seed and seedsmen should be most interested in the eradication of this pest. All the old stems should be burnt to destroy any pupæ that may be upon them, and the seeds sifted so as to retain the pupæ, while the seeds, being smaller, would pass through.

Mice.—The common or house-mouse (*Mus Musculus*) needs no description, and its depredations in vineries, stores, fruit-rooms, and seed-rooms, as well as in the open garden, are but too well known. The Long-tailed Field-mouse (*Mus sylvaticus*) is also responsible sometimes for a deal of injury in gardens, nurseries, and fields, by digging up corms, bulbs, and destroying young trees. It is larger than the former, and similar in colour to the common brown rat.

Remedies.—Stop up all holes by which houses are entered, with broken glass, or stones and cement. Encourage a good mouse cat or two in the potting-shed or even fruit-houses, or allow them a small hole somewhere for egress and ingress. The Perpetual Mouse-trap is a very useful invention, and requires emptying frequently, but no setting. The bait is as secure when the mice are inside as when outside. This trap may also be employed for the long-tailed species.

Nut-weevil (*Balaninus nucum*).—The perfect weevil is only $2\frac{1}{4}$ to nearly 3 lines long, and black, but covered with gray scales, and having rusty legs and a long, bent, reddish-brown beak supporting elbowed antennæ on its middle. The females pierce young hazel-nuts and filberts with their beak early in summer, laying a single egg in each. This gives rise to a fleshy, legless, white maggot with a brown head. It feeds upon the kernel, often causing the nut to fall prema-

turely, but finally bores its way out and hibernates in the earth till spring.

Remedies.—Choice filberts should not be planted in proximity to plantations or copses of hazel. Practise good cultivation, manuring the trees and digging the ground annually; many of the hibernating maggots will be destroyed or turned up to frost and birds. Collect and burn fallen nuts before the grubs have time to leave them. The old weevils might be beaten or shaken down on a cloth spread beneath the trees in the early morning during May and June, or even later if still present.

Pea Moth (*Endopisa proximana*).—The forewings of this little moth measure $\frac{1}{2}$ inch in expanse, and are olive-brown, with an eye-spot and a few yellowish lines. The caterpillar lives in pea-pods, and is dirty-white, with a brown head. The moths make their appearance in June, and generally lay one egg on each pea-pod. The egg gives rise to a caterpillar, which pierces the wall of the pod and feeds on the peas during summer, rendering them moth-eaten.

Remedies.—When pea-pods are pulled green, a great many of the caterpillars would be destroyed in that way. Pods left hanging upon infested plants would still contain larvæ, and the plants in such cases should be pulled up and burnt immediately after the crop is gathered. Those caterpillars that are allowed to escape form a silken cocoon in the earth, and reside in it till spring, when they change to pupæ and reach the perfect state again in June. By trenching the ground, or digging it two spits deep, the cocoons would be buried too deeply for the moths to get up through the soil.

Plum Sawfly (*Hoplocampa fulvicornis*).—The perfect fly is of a shining-black, with yellow legs, often brownish-yellow, and four transparent wings, and generally lays one egg in the calyx of each flower of the Plum. The grub has twenty legs, and is whitish, or tinted with a testaceous hue, and the head is brown. It penetrates the young fruit, and feeds upon the stone while yet quite soft, so that the plums never attain full size, but drop. The grub takes four to six weeks to attain full size, and may leave one fruit to attack another, and finally pupates in the soil.

Remedies.—Make a practice of going through affected plantations of Plums every morning; collect the fallen fruits, and burn or bury them deeply. It would even be more certain of securing the grubs in the injured fruits if a cloth is spread under the trees and the latter lightly shaken to cause the grub-eaten plums to fall. Those showing an exudation of gum might even

be pulled off. By persisting in these methods the pest will be subdued.

Raspberry Beetle.—For description and remedies see under BUD AND FLOWER ENEMIES.

Rats.—The Norway Rat, now called the Common Brown Rat (*Mus decumanus*), is the only one with which the gardener has to contend. It is an unwelcome visitor in vineries, seed and potato stores, and many other places, where it proves extremely destructive if not exterminated or kept away.

Remedies.—A good cat should be encouraged in vineries where it is difficult to exclude rats. Feed it there, but not well, otherwise it will become lazy. A hole for egress and ingress should be left somewhere above the ground level. Wooden or box traps may also be used; and iron rat-traps, carefully hidden, may be placed in the runs of the enemy in houses from which cats are excluded. These remedies are safer than laying poison in fruit-houses. In vineries a wire or cord may be stretched tightly across, and near the place where the vine-rods bend, at the eaves of the house. Circular pieces of tin, with a hole in the centre, may be strung on the wire just where the rats would be most likely to climb the rods, so that in clutching at the obstruction in their way the tin would turn and throw the rats to the ground. In all cases, however, an effort should be made to exclude them from all houses by cementing up their holes, using brick-bats or broken glass to be bound in with the cement.

Red Grub of Plum (*Carpocapsa funebrana*).—Several other names have been given to this moth, which measures about $\frac{1}{2}$ inch in expanse. The fore-wings are gray, clouded with a much darker, or almost black hue, and having an eye-spot near the outer end. The caterpillar

is pale-red, with a black head and brown neck. The female lays an egg on each fruit early in June, and the caterpillars pierce the fruit, living upon the soft parts around the stone, where they may be found in August, causing the plums to drop.

Remedies.—All fruits that drop prematurely should be collected immediately and burnt or destroyed. Trees that are known to be infested should be shaken occasionally, and the fruits which drop treated in the same way. Soon after the plums drop, the caterpillars leave the fruit and seek a sheltered place, generally in the crevices of the bark, where they spin a cocoon and pass the winter. Scrape the trees to remove all loose material and cocoons, burning the scrapings directly.

Snake Millipedes.—For remedies see Millipedes, under ROOT ENEMIES.

Wasps (*Vespa vulgaris*).—The mischievous character of wasps to many soft fruits during the time they are ripening is but too well known.

Remedies.—Open-mouthed bottles, partly filled with water, and strongly flavoured with syrup, molasses, London stout, or something similar, may be hung up in vineries, or amongst the branches of wall-trees. Attracted by the scent, many wasps will be lured to their destruction. Valuable bunches of grapes, or even other fruits that are intended to be kept for some time, may be covered with gauze, fine muslin, or tissue-paper, to exclude wasps. In the open garden, pears, plums, peaches, gooseberries, and others may be saved from destruction by elevating a hand-light upon bricks amongst the trees; make a small hole in the top of this, and place over it a sound one closely fitting the first. Under the bottom one lay some injured plums or pears cut open to attract the enemy. After feeding they often fly up through the hole in the bottom light, and are unable to find their way back. Hundreds of others, attracted by the buzzing, follow to their fate. When numerous they may be destroyed by burning sulphur beneath, or by submerging both the lights in a tub or tank of water. Hanging nests may be destroyed by means of pieces of rag dipped in boiling sulphur; these when dry may be tied on a long pole, lighted, and held under the nest in the dusk of the evening. Squibs might be lighted and pushed into the openings of nests in the ground, covered over, and the nests dug out when the wasps are stupefied or killed. By partly digging out a nest and filling the hole with water after the insects have settled, they

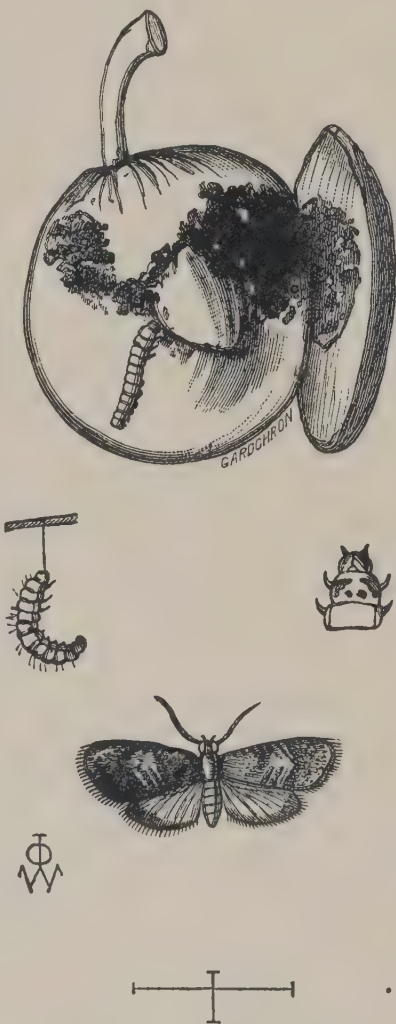


Fig. 94.—Plum Grub and Moth (*Carpocapsa funebrana*).

will be half-drowned, so that the nest can be dug out with safety. Every queen wasp destroyed in spring prevents the building of a nest.

LEAF ENEMIES.

Almond Aphis (*Aphis Amygdali*).—This is the chief pest of the Peach, whether under glass or on the open wall; but in the latter case, perhaps, does most harm, because less directly under the eye. It causes the young and growing leaves to curl badly, thus forming a protection for itself. The wingless viviparous females are dusky-green, rusty-brown, or almost black according to age.

Remedies.—Under glass it is a safe expedient to fumigate the trees before they come into bloom, whether aphides are detected or not. In bad cases, a small brush just kept moist with paraffin is used to brush off the insects as they cluster round the opening buds, but great care must be taken not to touch the latter. The young leaves, if infested, after they expand may be wetted with the syringe and dusted with tobacco-powder; this is a safe remedy, and is very serviceable for trees on open walls if accomplished on the first appearance of the enemy.

Apple Aphis (*Aphis Mali*).—The viviparous females vary greatly in colour, from the slaty-gray of those produced from eggs when the leaves unfold in spring to the dusky-green, yellowish, or rusty-red of later broods in June and July. It is a large fat aphis, and does great damage by causing the leaves to curl backwards, forming a safe hiding-place, and making the leaves and branches filthy with their excrement.

Remedies.—It is a good plan to wash the trees forcibly by means of the garden engine. This should be done on the first appearance of the insect, and the ground raked afterwards to destroy those knocked down. In bad cases the bark may be scrubbed with a strong solution of soft soap or Gishurst compound as for American Blight. Tobacco-water, made from 1 lb. of the former to 4 gallons of the latter, with $\frac{1}{4}$ lb. of soft soap added, constitutes a good wash with which to syringe the trees.

Asparagus Beetle (*Crioceris Asparagi*).—The perfect beetle is about $2\frac{1}{2}$ lines long, and has red shoulders, with bluish-green wing-cases, with red sides, and three whitish-yellow patches on each, often uniting. The grubs are dirty-olive, and may be found upon Asparagus from June till September in company with the perfect form. There are several broods in a season.

Remedies.—Large numbers of the beetle could be caught in the early morning by two persons, one carrying a tarred tray, while the other shakes down the insects into it. Another method

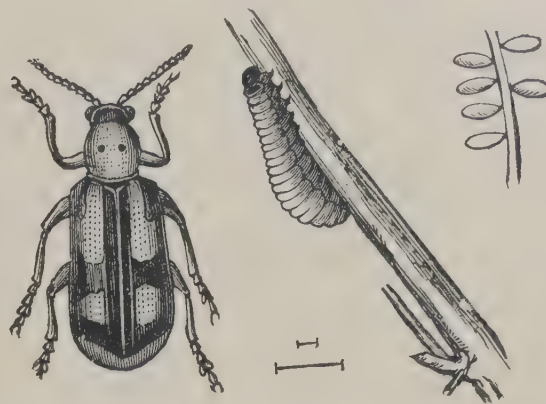


Fig. 95.—Asparagus Beetle (*Crioceris Asparagi*), Larva, and Eggs (all magnified). Natural length of egg and beetle shown by lines.

of destroying all the forms at the same time is to syringe the plants with water, about as hot as the hand can well bear, while another strews the ground with soot after shaking down the grubs. White hellebore powder might be used with which to dust the plants after cutting has been completed for the season. On the other hand, boys might be employed to collect the grubs and beetles when they have been knocked down.

Beet Carrion Beetle (*Silpha opaca*).—The beetle is about 5 lines long, black, and covered on the back with short, gray hairs. There are three ridges on each wing-case. The larvæ are flattened like a wood-louse, toothed at the edges, black, shiny, and are full-fed about the end of June. They pass into the ground, change their form, and come up again in two or three weeks.

Remedies.—The greatest damage is done while the plants are quite young. Good tilth and the application of a dressing of superphosphate, nitrate of soda, and other beneficial manures would counteract the pest by enabling the Beet to make rapid growth. Farmyard manure had best be applied to the ground in autumn, but artificial manures are best in summer, because they afford nothing which would encourage the beetle.

Beet Fly (*Anthomyia Betæ*).—The perfect form of this insect is a small, two-winged, ashy-gray fly, with darker markings and bristly hairs on the body and legs. The grubs are legless, and dirty-white, with two black processes at the head by which they pierce their way into the tissues of the leaves of Beet, and which they reduce to a mere skin.

Remedies.—Should the pest make its appearance in the leaves of young plants in garden cultures, the affected leaves should be removed

and burnt, to prevent later broods. Dressings of superphosphate and nitrogenous manures have been found beneficial, doubtless because they encouraged the rapid growth of the plants.

Begonia disease (*Tarsonymus*).—Properly speaking, this is not a disease, but an insect pest. The young leaves, flowers, and shoots assume a crippled, rusty appearance as a result of injury done by a small mite only half the size of Red Spider, and being white or colourless, not readily detected without the aid of a pocket-lens, should be looked for on those leaves just commencing to reveal its presence. The same or an allied mite attacks the young leaves of many other kinds of plants both under glass and in the open air. It is often found on Gesneriads, Acanthads, Cyclamens, Bouvardias, Primulas, &c.

Remedies.—The same causes which induce the rapid multiplication of Red Spider would also operate here. The gardener should always be on the alert for the first attack, and not wait till the leaves become brown and the flower-buds and young leaves drop, because by that time the plants are in all probability ruined for a season. Irregularities of temperature and moisture, cold draughts, and anything that would cause a check to growth should be avoided. When the mite makes its appearance in a batch of young plants the latter should be lightly syringed, then dusted with flowers of sulphur, especially about the buds and under-side of the leaves where the insects abound. Thorough syringing with a strong solution of Gishurst Compound, or anything containing sulphur, will also be found serviceable. Dipping the affected plants in weak tobacco-water has also proved effective. Another remedy is to lightly fumigate the house containing the plants once a week during the critical period of growth, or even as a preventive. In the case of Codæums and young Vines, a good cultivator found a safe and certain remedy in syringing the plants with water from a tank in which a bag of soot had been placed.

Black Aphis (*Aphis Rumicis*).—The wingless, viviparous females are fat, velvety-black, and get so crowded sometimes that they have to stand on their heads to get at the plants infested. Broad and Long Pod, and Dwarf or French Beans suffer most from their ravages.

Remedies.—The attack on Broad and Long Pod Beans is commenced at the top and continued downwards upon the stem and leaves, therefore it is a good plan to remove the tops after some of the lower pods have set. Place

them in close baskets with the aphides upon them, and burn or bury them deeply. Syringe infested Dwarf Beans in their young stages with strong soap-suds, but later on with clean water for the sake of the pods. Good culture and supplies of clean water or liquid manure will often enable the plants to make good growth in spite of the aphids.

Black Vine Weevil (*Otiorhynchus sulcatus*).—The weevil is $4\frac{1}{2}$ lines long and black. The wing-cases are deeply furrowed, and thinly covered with grayish-yellow scales. The grubs are fat, legless, curved, dirty-white, thinly hairy, and may be found at the roots of various plants from August till the following spring.

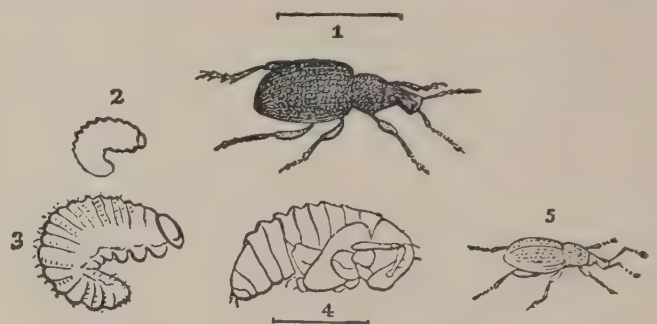


Fig. 96.—Black Vine Weevil (*Otiorhynchus sulcatus*).
1. Weevil. 2, 3. Larva (natural size and magnified). 4. Pupa. 5. *O. picipes* (see p. 83).

The perfect insect is sometimes very injurious to Vines, eating the leaves, shoots, flowers, and fruit. Strawberries are occasionally attacked.

Remedies.—The weevils feed by night, and hide by day in the crevices of walls, under clods, boards, &c. Crevices may be stopped up, and all shelter removed save some boards, which may be placed in the vineries and other places as traps. Spread a white sheet beneath the Vines by day, then take a bright light into the houses at night and suddenly turn it upon the weevils as they are feeding; the Vines may also be tapped, and the weevils will drop on the cloth, when they may be quickly collected and destroyed.

Blue Cabbage Flea (*Haltica consobrina*).—This beetle is oblong, violet, shining, and only $1\frac{3}{4}$ line long. The wing-cases are finely punctured. The six-legged maggot, when hatched, pierces its way into the leaves of cabbages and turnips, feeding upon the soft tissues, which it tunnels into galleries. There are several broods in a season, but the early ones do most damage while the plants are young.

Remedies.—Ground that is known to be infested with this beetle should be deeply trenched in winter to bury the pupæ hibernating in it. Hoeing and rolling between the rows of plants destroy the beetles in large numbers. Good culture favours the rapid growth of the plants.

at a time when the beetles are most likely to do them harm. Therefore watering or appli-

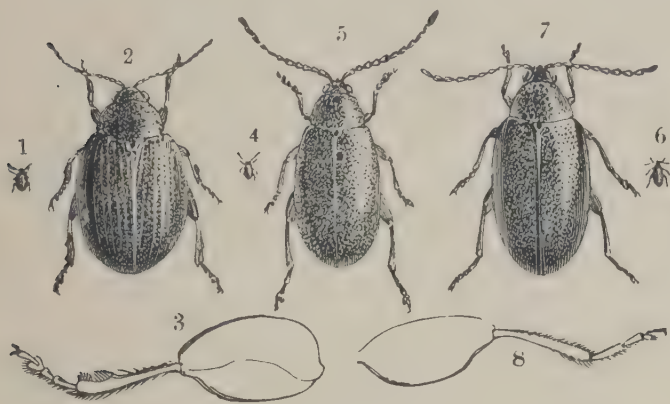


Fig. 97.

1 and 2, Hop Flea (*Haltica concinna*), natural size and magnified; 3, hind-leg, magnified; 4 and 5, Blue Cabbage Flea (*H. consobrina*), natural size and magnified; 6 and 7, *H. obscurella*, natural size and magnified; 8, hind-leg, magnified.

cations of weak liquid manure are beneficial for the same reason.

Brown Tail Moth (*Porthesia chrysorrhœa*).—The perfect moth measures $1\frac{1}{4}$ inch to $1\frac{1}{2}$ inch across the expanded wings, and is wholly of a satiny-white in nearly all cases, with a golden-brown tail. The caterpillar is black, covered with reddish hairs, and has a white stripe on each side. It sometimes attacks the Apple in May and June, and being one of the social caterpillars, lives in colonies, protected by a web, when not feeding.

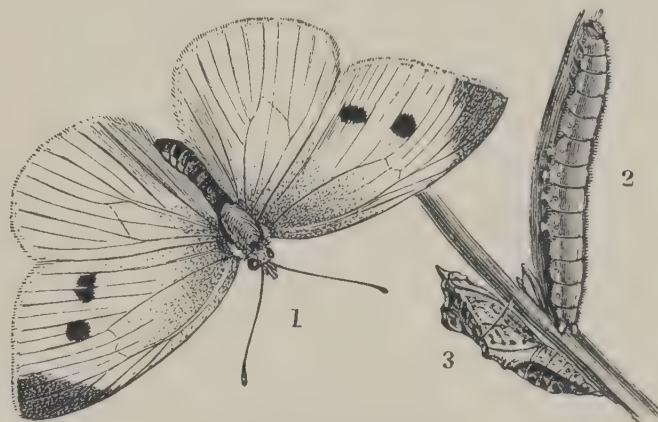
Remedies.—The caterpillars are easily detected by the webs, which should be collected while the occupants are still young and at home. Wear pruning gloves to prevent the hairs of the caterpillars from irritating the skin, and carry a pail containing quicklime or tobacco-water, into which the webs and caterpillars may be dropped. On a large scale a tarpaulin may be placed beneath the trees and the webs beaten down upon it, when all the caterpillars should be collected and destroyed immediately before passing on to the next tree. The full-fed larvæ lay up amongst rubbish about the foot of the tree, or amongst nettles and other weeds at the roots of hedges.

Cabbage Aphis (*Aphis Brassicæ*).—The large, fat, wingless females are covered with a mealy, white powder. They infest the leaves of all the Brassica tribe, including Turnips, and are most injurious to young plants, because they settle and multiply in the crowns amongst the young leaves, greatly crippling and turning them white or yellowish.

Remedies.—Good drenchings of clean water will knock down the aphides for a time, but do more good by encouraging vigorous growth. In cases of bad attack, the worst leaves may be cut

and burnt; then a good drenching of strong soap-suds, with a little tobacco-water in it, applied to the young plantations.

Cabbage Butterflies.—There are three closely-allied species of butterfly that infest the cabbage tribe; all produce two broods each season, and are similar in habit. The Large White (*Pieris Brassicæ*) measures $2\frac{1}{3}$ inches to $2\frac{2}{3}$ inches across the wings, which are white with a black tip and base, and two spots in the case of the female only. The caterpillars are yellowish, spotted with black, downy, and make their appearance in April to June, and again in July and August, as do those of the other species. The Large White also infests Tropæolums. The Small White (*Pieris Rapæ*) measures $1\frac{5}{8}$ inch to $2\frac{1}{8}$ inches across the wings, but is otherwise very similar to the former. The caterpillar is green, with a line of yellow spots on each side, and softly downy. It feeds on Mignonette, as well as the plants previously mentioned. The Green-veined White (*Pieris Napi*) measures from $1\frac{1}{2}$ inch to

Fig. 98.—*Pieris Rapæ*.

1. Small White Cabbage Butterfly. 2. Caterpillar. 3. Pupa.

nearly 2 inches across the wings, which are white with a greenish tint, and black veins, a black tip, and one or two spots. The caterpillar is green, with a line of red spots on each side, surrounded with yellow. All three are common, and widely distributed.

Remedies.—When the caterpillars are full-fed they crawl into sheds, sheltered places on walls, fences, and similar dry places, where they change to curious hunchbacked pupæ of a gray colour, suspended by a silken thread over their backs. Children may be set to collect them for a small reward per hundred. The caterpillars may be collected in the same way in gardens. Sunless, wet weather and cold rain often proves very destructive to the caterpillars by the wet food causing excessive purging. The garden engine might produce the same result if plied during the evening for three successive nights, using cold spring-water. The Large White lays its eggs in clusters on the under face of the leaves: and

these, if collected and destroyed, will prevent so many caterpillars from being hatched out.

Cabbage Moth (*Mamestra Brassicæ*).—The moth measures about $1\frac{3}{4}$ inch across the wings, which are dark-gray with black markings, and

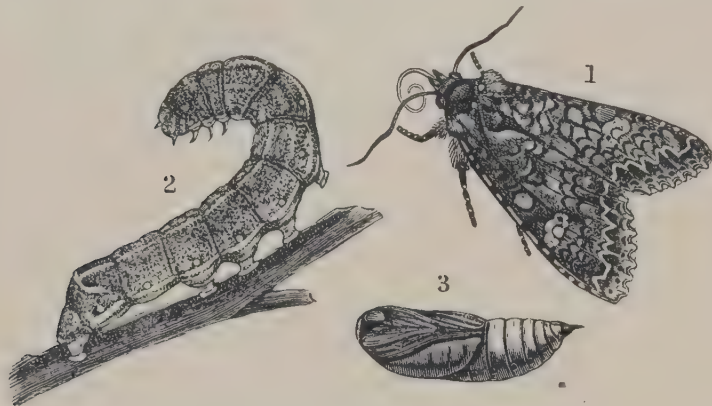


Fig. 99.—Cabbage Moth (*Mamestra Brassicæ*).
1. Moth. 2. Caterpillar. 3. Chrysalis.

a whitish spot near the middle. The caterpillar is dark-gray after attaining some size, with a line of white spots on either side, and infests various members of the Brassica tribe, principally during September, often eating into the heart of Cabbages.

Remedies.—Hand-picking is tedious and troublesome, but is the surest remedy, and might be accomplished by children at small cost. The matter should have early attention, particularly in the case of Cabbages, before the caterpillars eat their way into the hearts. When they attain some size they often pass the day in the ground and feed at night. A good plan, therefore, would be to spread soot and gas-lime upon the ground and round the plants, but not quite touching the stems. The gas-lime should be exposed to the atmosphere for two or three months to render it harmless to the Cabbages. Deep trenching in winter buries the pupæ too deeply to get up again, if the top spit is turned into the bottom and a good sprinkling of gas-lime placed over it. The chestnut-red pupæ should also be collected and destroyed when detected in digging.

Cabbage Powdered-wing (*Aleyrodes proletella*).—The perfect insect is a minute fly with four snowy wings and a dusky spot in the centre of the front ones, also a black head and shoulders, and a yellowish body. The females lay their eggs in clusters on the lower surface of the Cabbage leaf, and the larvæ, when hatched, scatter themselves over the leaves, settle, and get covered with a white scale, under which they live securely, sucking the juices of the leaves, sometimes doing them considerable injury, till they reach the perfect state to repeat the same process, for there are several broods in a season.

Remedies.—When Cabbages get very badly infested and spotted or withered with the fly, the worst leaves should be cut off and burnt, to destroy the insects under the scales, and also any eggs that may be there. A syringing with strong soap-suds or tobacco-water would act as a deterrent, though less effective than the burning of infested leaves.

Carrot Aphis (*Aphis Dauci*).—The wingless, viviparous females of this plant-louse are small and green, or sometimes yellowish, tinted with red. They infest the leaves of Carrots in June and July, and in bad cases entirely check their growth, rendering them useless.

Remedies.—When the cultivator has reason to fear that his plants suffer from this pest, he should examine them in good time and syringe his plants on the first appearance of the aphis with strong tobacco-water, having a little soft soap in it to make it adhere. Another sure remedy is to dust the crowns of the plants with tobacco-powder early in the morning while the plants are wet with dew, or they may be syringed on purpose to wet them.

Celery Fly (*Tephritis Onopordinis*).—This two-winged fly measures $\frac{1}{3}$ inch to $\frac{1}{2}$ inch across the expanded wings, and has a brown body covered with black hairs. The wings are variegated, with a zigzag brown band. Eggs are laid upon

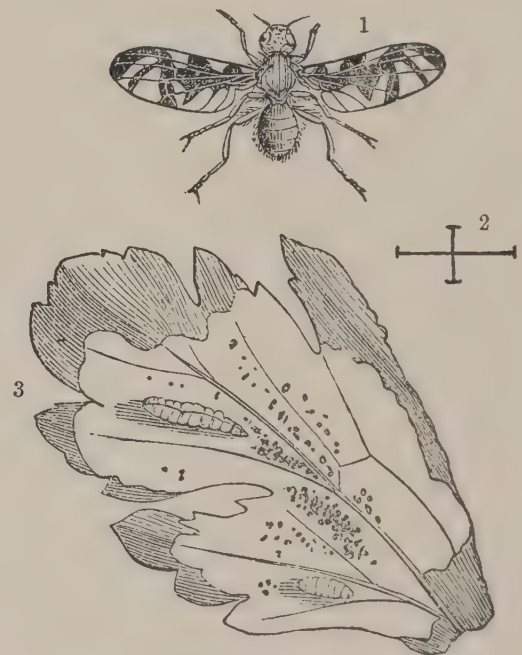


Fig. 100.—Celery Fly (*Tephritis Onopordinis*).
1. Fly (magnified). 2. Lines showing natural size. 3. Larva and pupa figured on blistered leaf.

Celery and Parsnip leaves, and the grubs tunnel into the soft tissues between the two skins, making pale-brown galleries or patches, often destroying the whole leaf. The insects appear in large numbers during May, and the grubs prove very destructive at that time, seeing that the young plants have but few leaves. There are several broods during the season.

Remedies.—To enable the plants to make good headway against the fly, they should be strong before they are planted out and well watered afterwards, using weak liquid manure occasionally. During June, or as soon as the least trace of the enemy is observed, the cultivator should go over his plants and squeeze the blistered portions between the finger and thumb, so as to destroy the grub. Very bad leaves and the affected portions only of others may be removed and burnt, but no green portions should be removed if it can be avoided. The leaves may be dusted while wet with a mixture of one part gas-lime, one of quicklime, and two of soot in the dry state, to drive the flies away. Trench deeply in winter, using a good sprinkling of gas-lime over the top spit when turned into the bottom to destroy the pupæ.

Cherry Aphis (*Myzus Cerasi*).—The Black Fly of the Cherry is entirely different from that of the Bean. The wingless females are somewhat flattened, black, and shining. They infest various kinds of Cherries in early summer, but they seem to prefer the Morello, on which they multiply till the leaves of whole trees are black with them and their filthy excrement.

Remedies.—This species is rather hard to kill; therefore the trees might be syringed at sundown with a decoction of tobacco and water at the rate of 1 lb. of coarse shag steeped in 4 gallons of water, to which 2 oz. of soft soap has been added to make it adhere. The trees should be washed forcibly with the garden engine the following morning to knock down the stupefied aphides and clean the trees of their excrement. Another remedy is to boil 4 oz. of quassia chips in a gallon of water for ten minutes, then strain off the chips and add an ounce or two of soft soap, and use in the same way as previously mentioned.

Chrysanthemum Leaf Miner (*Phytomyza nigricornis*).—Here we have a small, black, two-winged and hairy fly, with much the same habits as the Celery Fly, but only $\frac{1}{8}$ inch in expanse. It attacks various plants, including Peas and Turnips, but annual, perennial, and shrubby (Marguerites) Chrysanthemums constitute its favourite food. It tunnels the leaves, sometimes entirely destroying them, whether under glass or out-of-doors. Under glass it breeds all the year round.

Remedies.—Syringing the leaves of the plants occasionally with tobacco-water has been found fairly effective in driving the fly away by rendering the leaves distasteful to the females that come to lay their eggs. A sharp eye should be

kept upon the plants, and upon detecting the first traces of galleries in the leaves; the latter

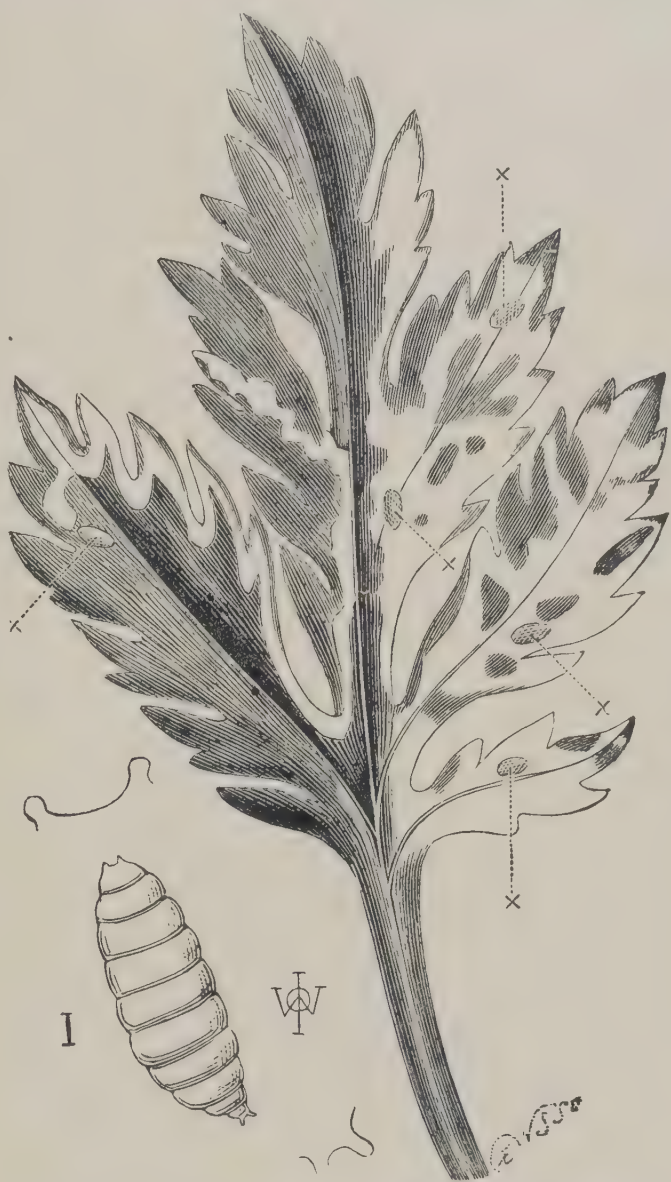


Fig. 101.—Chrysanthemum Leaf Miner (*Phytomyza nigricornis*).

should be squeezed between the finger and thumb to kill the grubs, the position of which

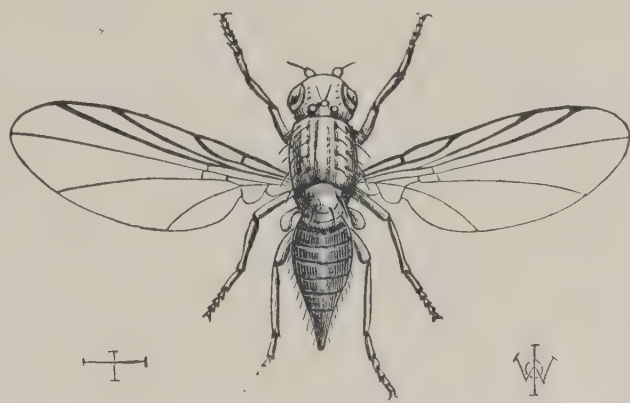


Fig. 102.—*Phytomyza nigricornis*, the perfect insect.

is generally easily detected. Badly-infested leaves should be collected and burnt; but in all cases early attention will save much mischief.

Clay-coloured Weevil (*Otiorhynchus picipes*, see fig. 96 (5)).—The perfect weevil is $\frac{1}{4}$ inch long or slightly over, and dull blackish-brown, but so closely covered with brown and gray scales as to give it the colour of clay, as implied by the name. The wing-cases are

striated and furnished with eye-like depressions. The snout is short and stout. The grub is fat, legless, dirty-white, and feeds on the roots of various plants, while the perfect weevil is destructive to the leaves and other parts of Vines, Raspberries, and Peas, doing great harm when numerous.

Remedies.—The perfect weevils may be found from the latter part of April onwards, and have the same habits as the Black Vine Weevil, which see for remedies when Vines under glass are attacked. In the case of Raspberries long narrow trays should be constructed, covered with moist tar, and carried along between the rows by men or boys, so that while one carries a tray another should carry a lantern, and tap or shake the canes over the trays, when the weevils will drop into the same and be held fast by the tar. This should be done after darkness sets in, as they only feed by night and hide under clods by day. The operation should be repeated several nights in succession until the weevils get scarce. Sweeping-nets might also be employed to brush along the rows of Raspberries and Peas, to collect the weevils after nightfall.

Common Flat-body Moth (*Depressaria applanata*).—This small moth has the body depressed, and measures somewhat under an inch in expanse, and has the fore-wings of a reddish-brown, clouded with a dusky hue, and having some black and white markings. The slender caterpillar is green, with a darker line on the back, and lives in the folded leaves of various umbellifers, including the Carrot and Parsnip, during June and July.

Remedies.—The solitary wasps prey largely upon the caterpillars, constituting a natural check. When, however, they become troublesome, the plants may be shaken or agitated with a stick to cause the caterpillars to drop, when a good dusting of lime and soot may be given to prevent their getting up again. Umbelliferous weeds should not be permitted to grow in the neighbourhood of Carrots and Parsnips, otherwise the moths would be likely to multiply and prove troublesome.

Currant Aphis (*Myzus Ribis*).—The wingless females of this insect are bright-yellow, with a double row of green spots on the back, furnished with pin-headed hairs. They infest the under surface of the leaves of Red and Black Currants.

Remedies.—Where troublesome, this aphis may be destroyed by washing the under side of the leaves with the garden engine, using a

mixture of soft soap and tobacco-water, made by dissolving 15 lbs. of the former in 9 gallons of water, to which the juice of $\frac{1}{2}$ lb. of tobacco

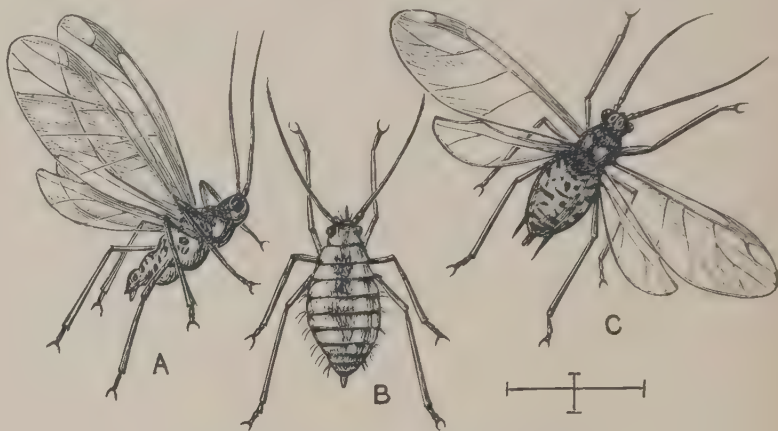


Fig. 103.—Currant Aphis (*Myzus Ribis*).
A, Male. B, Apterous female. C, Winged female.

has been added; to each gallon of the mixture add 36 gallons of water, and apply the liquid to the bushes rather forcibly.

Diamond-back Moth (*Plutella Cruciferarum*).—The perfect moth measures only about $7\frac{1}{2}$ lines across the fore-wings, which are grayish-brown with darker markings, and having a whitish-yellow, three-lobed band along the inner edge. The caterpillars are $\frac{1}{2}$ inch long when full grown, tapering to each end, and vary from yellowish to apple-green according to age. There

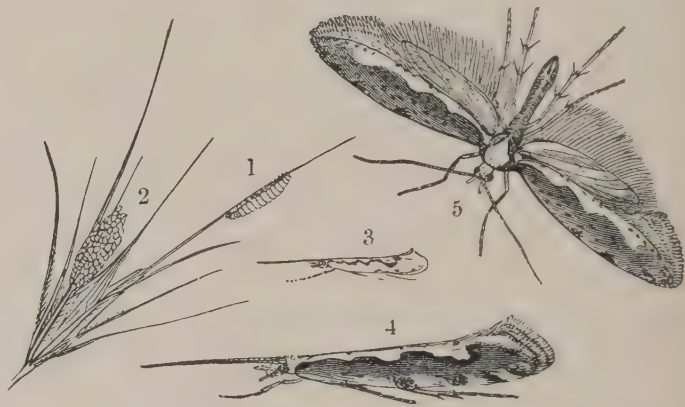


Fig. 104.—Diamond-back Moth (*Plutella Cruciferarum*).
1. Caterpillar. 2. Eggs. 3. Moth (all natural size). 4, 5. Moth (magnified), at rest and flying.

are two broods in a season, namely, in June and July, and again in September. They infest many crucifers, but particularly Turnips and Cabbages, the leaves of which they eat away to the ribs, working from the under side.

Remedies.—A dusting of 3 parts of soot and 1 of lime, mixed and finely powdered, has been found beneficial. Before doing so, it would be advisable to make a light broom of slender twigs, and brush along the lines of Turnips or Cabbages to knock down the caterpillars, then a boy might follow behind and apply the mixture, dusting it over the plants and between the lines. Heavy rains greatly injure the caterpillars, while they start the plants growing; water might therefore be applied with the

garden engine. A dressing of nitrate of soda and salt, at the rate of $\frac{1}{2}$ cwt. of each per acre, is also very beneficial, especially in moist weather, as it sets the crops growing—a matter of great importance in cases of this kind.

Figure-of-8 Moth (*Diloba cæruleocephala*).—The perfect moth measures $1\frac{1}{3}$ inch to $1\frac{1}{2}$ inch across the wings, which are dull-gray tinted with rose, and have two markings on the middle of each



Fig. 105.—Figure-of-8 Moth (*Diloba Cæruleocephala*).

1. Moth. 2. Caterpillar.

like the figure 8. The caterpillar is pale-yellow with a blue head, and appears in June, sometimes doing damage to the leaves of Apple and other trees.

Remedies.—Should the caterpillars of this moth prove troublesome, they may be destroyed by spraying the trees with Paris-green at the rate of a tea-spoonful of the poison, finely powdered, to 2 gallons of water. On a larger scale use 1 lb. of Paris-green to 200 gallons of water. This should be done at the end of May or beginning of June, when the caterpillars first make their appearance; they do not live in webs. Their destruction is effected by eating the poisoned leaves.

Garden Chafer (*Phyllopertha horticola*).—This beetle is 4 to 5 lines long, and has a bluish-black head and shoulders, while the wing-cases present a mixture of yellow, red, and brown, and the body is hairy. It appears in May and June. The six-legged grubs are yellowish-white, but of a leaden colour at the tail end, and feed on the roots of grass for about three years, doing great damage to the turf. In summer they reside about an inch beneath the surface, but at greater depths in winter.

Remedies.—Sometimes they exist in vast numbers, and the perfect beetles cluster densely upon the leaves of various fruit-trees, Roses and others. In these cases they may be shaken

down upon cloths early in the morning or late in the evening, as they fly by day, thus escaping. Collect and destroy them. The grubs may be destroyed by watering the grass in autumn with a gallon of gas-liquor in 9 gallons of water, or with a strong solution of salt and water. Encourage starlings, rooks, and thrushes, which destroy the grubs in large numbers. Roll the grass in spring to settle the turf, and encourage the grass to grow with such artificial manures as nitrate of soda, and potash, also with dressings of lime, decayed vegetable matter from the rubbish heap, or old potting bench soil.

Garden Pebble Moth (*Pionea forficalis*).—Across the expanded wings this moth measures 1 inch to $1\frac{1}{8}$ inch. The fore-wing is whitish-yellow, shaded with pale-brown, with two brown and two gray lines running obliquely. The caterpillar is yellowish-green, with a line of darker spots on either side, and tapers to either end. They feed on Cabbage, Horse-radish, and Turnip leaves during June and July, and again in September and October, being double-brooded.

Remedies.—Children could be employed to pick the caterpillars off the leaves of Cabbages, as they are large and easily noticed if at all plentiful. The leaves of Horse-radish and Turnips might be wetted with the syringe and dusted with white hellebore powder mixed with three or four times its bulk of flour; or an infusion of it may be used and syringed upon the plants. Make this infusion by pouring 2 gallons of boiling water over 1 oz. of the powder, dissolve 1 oz. of common glue in a gallon of water, mix the whole together, and allow it to cool before using.

Gooseberry and Currant Sawfly (*Nematus Ribesii*).—In the perfect state this is a fly with four transparent wings and a yellow body, or the hinder part may be orange. The caterpillars are bluish-green with black spots, a black head, 6 proper feet, and 14 suckers, making 20 in all. There are several broods, the first appearing as the leaves of the Gooseberry and Red Currant unfold in spring; the caterpillars of the last brood hibernate in the soil till spring. The eggs are laid on the under side of the leaves, and the caterpillars may be found in clusters in the very young stages.

Remedies.—Where the sawfly is known to be prevalent, a close watch should be kept upon the young leaves in spring for the first appearance of the caterpillars, which may easily be collected while still in clusters. The bushes may then be dusted over the lower parts with

sulphur while wet with dew, or they may first be syringed with water and dusted. While the fruits are still quite small, the bushes may be treated with white hellebore, as prescribed for



Fig. 106.—Gooseberry and Currant Sawfly (*Nematus Ribesii*).

1. Shoot of Gooseberry. 2. Eggs. 3. Larva. 4. Pupa. 5. Perfect insect.

the Garden Pebble Moth, except that glue should not be mixed with the decoction of powder. Pyrethrum powder is considered harmless except to insect life, and the Californian sort named buhach or the Persian insect powder might be employed to dust the bushes instead of white hellebore. During winter, when the ground is being dug, the soil to the depth of 3 or 4 inches may be removed from beneath the bushes and placed in the area between the rows; cover the roots with fresh soil taken from the middle; and use a good sprinkling of gas-lime to mix with the old soil in digging, so as to destroy the caterpillars lying dormant in their cocoons.

Green Fly (*Rophalosiphon Dianthi*).—The wingless, viviparous females of this species are usually pale-green, but vary from that to rusty or brownish-yellow, or a reddish hue. The name "Green Fly" might be applied to many other species, but that under notice is extremely common, and is known to infest 60 to 70 species of plants, including many valuable garden subjects, such as Carnations, Fuchsias, Peaches, Potatoes, Hyacinths, Tulips, and other bulbs. Other green aphides of a harmful character are Siphonophora Pelargonii, infesting show Pelargoniums, and S. Pisi, the large aphis of garden Peas and Sweet Peas. Aphis Cratægaria, or an allied species, infests Gooseberry and Red-currant bushes.

Remedies.—Under glass, fumigation in some of the numerous ways at present in vogue may be employed to destroy Green Fly, and should be effected before the plants come into bloom, and after the latter is past, if necessary. Out-of-doors affected plants may be syringed with a solution of soft soap and water, as for the

Currant Aphis above detailed. The tops of the young shoots of Gooseberry and Red Currant bushes infested should be cut off and burnt before the syringing is given.

Lackey Moth (*Clisiocampa neustria*).—The perfect moth measures somewhat under, to a little over, $1\frac{1}{2}$ inch across the wings, which vary from pale-yellowish to sandy-red, with two brown lines running obliquely across them. The caterpillars appear in May and June, sometimes doing great damage to orchard and forest trees. They are variously coloured with white, orange, black and blue and silvery-blue lines, and clothed with brown and golden-brown hairs.

Remedies.—Keep a sharp look-out for the earliest appearance of the caterpillars, which live in communities covered by a web. In the case of dwarf trees, a man or boy could hold a pail, containing some water or soap-suds, beneath the webs, while another pulls down the latter with their load of caterpillars. A cloth may be spread beneath standard or orchard trees while the webs are brought down with a pole, or, better still, by the cutting of the shoots infested, with a long-handled tree-pruner. Collect cocoons found upon the trees during July and August;

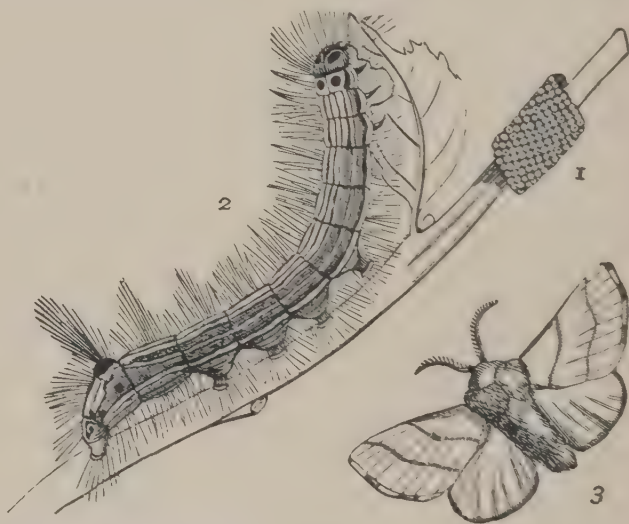


Fig. 107.—Lackey Moth (*Bombyx (Clisiocampa) neustria*).

1. Eggs. 2. Caterpillar. 3. Moth.

destroy eggs upon the shoots in winter; and keep the ground about the trees clear of all rubbish.

Lunar-spotted Pinion Moth (*Cosmia pyralina*).—The fore-wings of this moth measure $1\frac{1}{6}$ inch to $1\frac{1}{4}$ inch in expanse, and are reddish-brown, with a central patch and two lines of a blackish hue. The hind-wings are gray. The caterpillars are smooth, pale-green, with three paler lines on the back, and a yellowish line edged with black on either side. They appear in April and May, and sometimes do damage to Plum, Pear, and Apple-trees. The perfect moth appears in August, but is local in distribution.

Remedies.—As the caterpillars live in bundles of leaves tied together with silken threads, dwarf trees and those on walls may be cleared of the pest by a man and a boy, one of whom could hold a tarred tray beneath the bundles of leaves, while the other disturbed the caterpillars by loosening the leaves. The cocoons may be found later on in the same bundles of leaves, or upon the surface of the ground if any of the caterpillars have escaped, and may then be collected. On a large scale, and in the case of standard trees, spraying with Paris-green in April would destroy those caterpillars which leave their retreat to feed, or which eat through the bundles of leaves.

Magpie Moth (*Abraxas grossulariata*).—Across the wings this moth measures $1\frac{1}{2}$ inch to $1\frac{2}{3}$ inch. The fore-wings are white, with transverse, interrupted bands of black spots, and some orange at the base and middle. The caterpillars are white, with several rows of black spots, of which those along the back are very prominent. The eggs are laid upon the bushes about the end of summer, and hatch in September, when the caterpillars feed for a time, then hibernate amongst leaves and rubbish till the following May. They feed upon Currants, Gooseberries, and other subjects till full-sized, when they



Fig. 108.—Magpie Moth (*Abraxas grossulariata*) and Larva.

change to black pupæ, ornamented with orange rings, and may be easily noticed, suspended as they are upon the bushes.

Remedies.—Bushes that are known to have been attacked should be inspected during June and the beginning of July for the showy pupæ suspended in them. This could be done by boys. When the caterpillars commence the attack in September, the bushes may be sprayed with Paris-green, as prescribed for the Garden Pebble Moth, except where fruit is still hanging, in the case of very late crops. Immediately the leaves fall in autumn, collect the leaves very carefully and burn them, to destroy any caterpillars that may be hibernating amongst them. If the spray-

ing is properly done, however, all the caterpillars will get killed while still quite young.

Mottled Umber Moth (*Hybernia defoliaria*).—The male measures $1\frac{1}{2}$ inch to $1\frac{3}{4}$ inch



Fig. 109.—Mottled Umber Moth (*Hybernia defoliaria*).
1. Male moth. 2. Female moth. 3. Caterpillar (natural size).

across the fore-wings, which are pale-yellowish, marbled with yellowish-brown and dusted with brown. The female is wingless, and more like a spider than a moth. The caterpillars are reddish-brown upon the back, and feed upon the Apple and other trees of the Rose family during May and June.

Remedies.—The females ascend the trees during October and November to lay their eggs upon the stems, branches, and spurs, and their habits being precisely the same as those of the Winter Moth, the remedies for the latter will apply in this case.

Pale Brindled Beauty Moth (*Phigalia pilosaria*).—The expanded wings of this species measure $1\frac{1}{2}$ inch to nearly 2 inches across, and are pale-gray with a greenish tinge, and four slender, wavy lines across them. The caterpillars sometimes attack the Apple and Pear during May and June, and are grayish-brown tinted with red, and have four small projections on the back. They have only four sucker feet behind, on which they raise themselves when alarmed, and appear like pieces of dead wood.

Remedies.—The females are wingless, and crawl up the trees to lay their eggs during the first three months of the year. Tar bands should be tied round the trees at this period as for the Winter Moth, which see for other remedies.

Pea and Bean Weevils.—There are two species of weevils which are destructive to the young plants of Peas and Beans during March and April, after the warm weather commences. The Striped Pea Weevil (*Sitona lineata*) is 2 lines long, and black, with rusty-red horns, shanks, and feet. The wing-cases are striped

with white. The Spotted Pea Weevil (*Sitona crinita*) is smaller, being only $1\frac{1}{2}$ line to $1\frac{3}{4}$ line long. It is black, but closely covered with gray

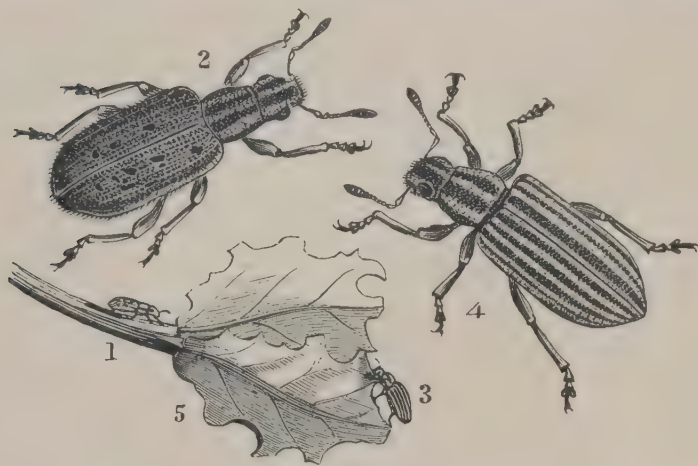


Fig. 110.—Spotted and Striped Pea Weevils (*Sitona crinita* and *S. lineata*).
1. Spotted Pea Weevil (natural size); 2, magnified. 3. Striped Pea Weevil (natural size); 4, magnified. 5. Leaf notched by weevils.

scales, and the wing-cases are finely bristly, with some black spots thinly arranged in lines. The horns, shanks, and feet are paler than in the other species.

Remedies.—Keep a sharp look-out for the weevils, especially upon the earlier sowings of Peas and Beans. If the leaves are being gnawed away from the edges inwards, weevils may be found upon them during the day while the sun is shining. If so, tarred boards or strips of cloth may be arranged along each side of the rows in the morning; after the sun has warmed the air, shake the plants over the boards, and the weevils, alarmed, will drop and be held fast. They do not attempt to fly, but can run quickly. Dusting the leaves with soot or wood-ashes while they are wet, makes the food unpalatable to the weevils.

Peach Aphis (*Myzus Persicæ*).—The wingless, viviparous females are rosy or rusty-red, with greenish horns and legs. They infest Peaches and Nectarines, but are neither so common nor so destructive as the Almond Aphis.

Remedies.—After the fruit is set, badly-infested trees, particularly those upon walls in the open air, might be syringed with tobacco-water at the rate of 6 gallons of the latter to 1 lb. of tobacco, with a little soft soap added. This should be washed off the following morning with clean water, which will cleanse and greatly benefit the foliage. Other remedies will be found under Almond Aphis.

Pear-leaf Blister Moth (*Lyonetia Clerckella*).—This tiny moth measures only 4 lines across the expanded wings, which are white, with a brownish blotch beyond the middle, followed by some transverse lines of the same hue. The

grubs are pale-green, and mine the leaves of Pears, Apples, and Cherries during May, June, and July, and again from August to October, the moth being double-brooded. They penetrate the soft tissue of the leaves, forming long tunnels and blisters, which become dark-brown and weaken the trees when the pest is plentiful.

Remedies.—Syringe the trees with soap-suds about the end of May or the beginning of June to prevent the moths laying their eggs upon the leaves. Collect blistered leaves as soon as they appear, as a result of both early and late broods, and burn them to destroy the grubs. Clear away fallen leaves in the autumn and burn them; give a sprinkling of gas-lime around the base of the trees to destroy the pupæ that may have escaped being raked up; plaster all the crevices of walls in the case of wall trees, and examine the shreds by which the branches are nailed to the wall, to collect and destroy pupæ. Spraying the trees with Paris green immediately after they go out of bloom would doubtless kill



Fig. 111.—Pear-leaf Blister Moth (*Lyonetia Clerckella*).
1. Blistered Pear leaf. 2. Caterpillar (natural size). 3. Magnified. 4. Pupa. 5, 6. Moth (natural size and magnified).

a great many of the grubs before they could penetrate the leaves.

Pear-leaf Mite (*Phytoptus Pyri*).—Closely allied to the Currant Gall Mite is another microscopical creature with four legs near the head, but which behaves in a different way. It penetrates into the soft tissues between the two surfaces of the leaves, causing the cells to become loose and spongy, thus forming small but variously-shaped blisters upon the surface of the leaves, and which are at first yellowish, but soon become deep-brown, and ultimately fall out, leaving holes. There are no galleries in the leaves like those of the Pear-leaf Blister Moth.

Remedies.—The same trees get affected year after year, and get weak and unfruitful if the pest is allowed to get very plentiful. Such trees may be grubbed up and burnt, to destroy the

mites in the new buds, unless they be very valuable. Cutting down and regrafting them might have the desired effect of getting rid of the mites. Where the blistered leaves are not too numerous, collect and burn them as soon as the blisters can be seen, to destroy the mites in them. Washing the foliage with insecticides would be useless, unless it could be determined

imparting the same hue to the leaves, which become filthy. A variety of the Hop Aphis (*Phorodon Humuli Malaheb*) may sometimes become troublesome by infesting the lower surface of the leaves in May and June.

Remedies.—On a large scale the same washes may be used as for the Currant Aphis. Another cheap remedy is to dissolve 7 to 10 lbs. of soft soap in 50 gallons of water to which the juice of 2 oz. of tobacco has been added. This may be applied with the garden engine, and the trees washed with clean water the following morning. An important point with these insects is to apply the remedies as soon as the pest is first detected, to prevent the foliage becoming curled and filthy. The young leaves in spring are very liable to be attacked and the growth of the shoots checked. The worst of the leaves attacked by the Clear-wing Aphis might be collected and burnt.

Red-footed Beetle (*Luperus betulinus*).—The perfect beetle is about 2 lines long or slightly over, and of a glossy black, except the legs and the base of the horns, which are reddish-yellow. In some districts it is very abundant, and usually preys upon Willows, but sometimes attacks Pear and Apple-trees, destroying the foliage during June and July.

Remedies.—Where the small, black beetles prove troublesome, an easy remedy would be to spread a white cloth under the trees and shake them down upon it. If this is done early in the morning, the beetles will then be sluggish and less liable to fly away before they are collected. A freshly-tarred cloth, or one saturated with paraffin, would be more effective in preventing flight.

Red-legged Garden Weevil (*Otiorhynchus tenebricosus*).—The perfect weevil is slightly under $\frac{1}{2}$ inch long, black, and rather glossy, with reddish-brown legs. The wing-cases are very finely wrinkled, with tufts of gray hairs in the depressions, and have very fine lines upon them. The larva or grub is fat, legless, dirty-white, and feeds upon the roots of various plants from August to April following, when it changes to the pupa stage, and a fortnight later reaches the perfect state. The weevils then prey upon the leaves, buds, and young shoots of many fruit-trees, particularly those trained upon walls, or in fact upon trees wherever they can find sufficient shelter. Where plentiful, they seem to prefer gardens, which they frequent, doubtless, because they find plenty of food. The grubs are equally as mischievous to the roots of bush fruits, Raspberries and Strawberries.

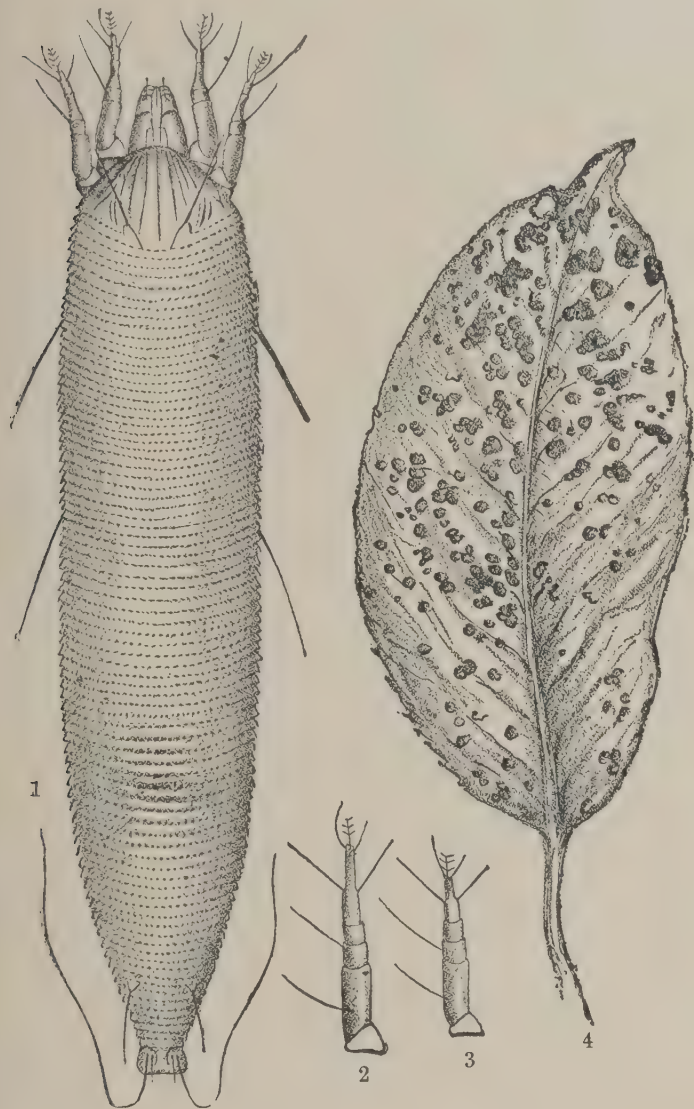


Fig. 112.—Pear-leaf Mite (*Phytoptus Pyri*).

1. Female. 2 and 3. Legs (magnified 550 times). 4. Infested Pear leaf.

when the mites come out of the leaves to pass into the new buds.

Phylloxera (*Phylloxera vastatrix*).—See under ROOT ENEMIES.

Plum Aphides.—At least three species are guilty of injuring the foliage of Plum-trees. The Plum Aphis (*Aphis Pruni*) is perhaps the most destructive, as it is the most common. The wingless females vary from green to light olive-brown, and are covered with a mealy powder. They cause the young leaves to curl up, and make them filthy with their excrement. Later on, the Clear-wing Aphis (*Hyalopteris Pruni*) covers the under surface of the leaves in dense masses, causing them to curl backwards. The wingless females are pale, glaucous or bluish-green, and densely covered with a mealy powder,

Remedies.—For methods of catching the perfect weevils on fruit-trees and bushes, see under Black Vine Weevil and Clay-coloured Weevil. Where the grubs of the Red-legged Garden Weevil are numerous and destructive, methods of destroying them must be undertaken in winter. When the ground between Raspberries and fruit bushes is being dug over in winter, the white grubs may readily be detected and collected by a boy following each workman digging. Dressings of soot, quicklime, and gas-lime may be given, taking care not to place the latter too near the bushes unless it has been exposed to the atmosphere for a month or more. Badly-infested Strawberries may be trenched down, putting the top spit in the bottom and placing a good sprinkling of gas-lime over it to kill the grubs. When the latter get into pots, the plants should be turned out, their roots washed, and repotted.

Red Spider (*Tetranychus telarius*).—In spite of the name, this is neither a spider nor an insect. The head and body are in one piece, thinly furnished with bristly hairs, as are the eight legs, and red or almost colourless according to age. It is really one of the spinning mites, hardly discernible to the naked eye except in large numbers, and lives and multiplies with amazing rapidity all the year round, provided the conditions are favourable. A fine web is formed on the under surface of the leaves of plants belonging to the most diverse families, and here it lives in colonies beneath the web. Dry conditions are most favourable to its multiplication, and these it most often finds on plants cultivated under glass. Out-of-doors it proves most troublesome in drougthy summers; and in any case its presence may be detected by yellow spots on the leaves, which continue increasing in area and number till the whole leaf looks yellow and sickly, or in other cases brown, and ultimately dies upon the plant or drops off.

Remedies.—Water is the great enemy to Red Spider, so that it can easily be kept in check in vineries, peach-houses, stoves, and similar places by a liberal use of the syringe, and the damping down of all available surfaces, particularly when the houses are being closed in the afternoon. When this is properly carried out in houses where a moist atmosphere is permissible, the cultivator has little to fear from the depredations of red spider. It is liable to increase with great rapidity during the ripening of Peaches, Figs, and Vines, but may again be reduced by clean water, or by heavy syringings with strong

soap-suds, or Gishurst compound, at the rate of 1 or 2 oz. to a gallon of rain-water, after the fruit has been gathered. It is a very common practice to paint the hot-water pipes in vineries with a mixture of sulphur and water to destroy Red Spider. On no account paint flues, or the Vines will run the risk of being injured or killed. In the open air, heavy rains prove effectual in checking Red Spider. During dry weather the garden engine should be plied vigorously upon Peach and other fruit-trees attacked, as well as herbaceous plants such as the Hollyhock, using clean water. Valuable plants can be cleansed very effectually by the use of a mixture of flowers of sulphur and water, or fairly strong soap-suds, separately or in mixture. The receipt given for the Currant Aphis would answer admirably if preferred to the above remedies. In any case, apply the remedy early before the pest has time to greatly injure the leaves; the under surface of the latter, particularly, should be well wetted.

Rose Aphides.—Roses are very liable to attack by at least two species of aphides, whilst two or more others are less frequent upon them. The most conspicuous, most abundant, and destructive, is *Siphonophora Rosa*, the wingless females of which vary from pale-greenish or yellowish to olive, slaty-gray, and red. *Siphonophora rosarum* frequently feeds in company with the former upon Roses of many kinds, both under glass and in the open air. It is much smaller, light or yellowish-green, and covered all over with pin-headed bristles in the wingless, female form.

Remedies.—Clean water, applied forcibly with the garden engine, is serviceable by washing the black filth and excrement from the foliage, but the aphides take shelter on the under side of the leaves, or if they get knocked down many crawl up the stems again in a few hours. In bad cases the Roses may be syringed with the juice of 1 lb. of tobacco in 6 gallons of water, with a lump of soft soap added, to make it adhere to the insects. This may be done late in the afternoon, and the bushes thoroughly drenched with clean water next morning. The operation should be repeated after seven days, if necessary, to destroy any aphides that may have escaped, or those that may have come from a distance.

Rose Sawflies.—These species of sawfly are characterized by four membranous wings and a process like a double saw at the tail end, used for making slits in the leaves or stems of plants for the purpose of laying and fixing their eggs.

and constitute a very numerous family even in Britain alone. Many of them live upon the leaves or in the stems of Roses, and the more common ones are often destructive. There are several species of *Hylotoma*, but all are similar in habit to *H. Rosæ*, which may be taken as a



Fig. 113.—Larva of Rose Sawfly (*Hylotoma Rosæ*).

type. The fly is $\frac{1}{3}$ inch long, and yellow, with a black head. The caterpillars are bluish-green, with two lines of yellow spots on the back, and a row of black ones on either side, and a dark head. They appear in May and June, and again in August and September, the fly being

its congener, and its caterpillar feeds upon Roses, Plums, and Pears, making holes in the leaves. Two to four broods are produced in a season, and the cocoons are formed in the ground. Another common species is *Blennocampa pusilla*—a shining black fly with grayish-brown wings. The caterpillars are short, fat, and green, with loose folds of skin hanging down on either side; the back is somewhat bristly, and the head brown. They roll the leaves into cylinders open at either end, tying them with threads, and thus form a shelter in which they feed. The perfect fly emerges from cocoons in the ground during May and June. *Lyda inanita* rolls the leaves in the same way as the previously-named species.

Remedies.—Taking the habits of the above, we have three distinct types to deal with, namely, those which feed exposed on the edges of the leaves and are easily detected, those which lie on the under surface and eat holes in the leaves, and those which roll the leaves and prove more troublesome to destroy. The first two kinds may, however, be destroyed wholesale by insecticides well sprayed on both surfaces of the leaves. If there are only a few bushes or a small bed, spray the foliage with Paris-green or London-purple (the former being most reliable, because less likely to hurt the foliage) at the rate of 1 tea-spoonful to 2 gallons of water. On a large scale use 1 lb. of Paris-green to 300 gallons of water. An infusion of white hellebore, prepared as for the Garden Pebble Moth, may be used instead. Flowers of sulphur mixed with water and sprayed on the foliage is another remedy sometimes employed. Those which live in rolled packets of leaves would also be destroyed by Paris-green or white hellebore should they eat any of the outer leaves, but some would be sure to escape; therefore hand-picking is more effective, even if a tedious process. The leaves of valuable Roses should be unrolled or loosened from their ties, and the caterpillars destroyed; but take care that they do not escape by letting themselves down with a thread, the ends of the leaves being left open for that purpose. Boys could accomplish this when shown how to perform it properly. Carefully collect and burn dead leaves beneath the Roses, so as to destroy the pupæ. When digging the ground, throw the soil from beneath the bushes on the middle of the rows, replacing it



Fig. 114.—Rose Sawfly (*Emphytus cinctus*).

double-brooded, and they eat the leaves from the edges to the midribs in a very short time. The cocoon is formed in the ground. *Emphytus cinctus* is also common, and feeds in the same way. *Cladius pectinicornis* is common on Roses. The fly is $\frac{1}{3}$ inch long, glossy-black, with scattered gray hairs, and pale, smoky wings. The caterpillars are flattened, tapering each way, and are dark-green, with three rows of warts on each segment, and each wart is furnished with a long brown hair. They lie flat on the under surface of the leaves, and eat holes in them. There are two broods, and the cocoon is formed between dead leaves. *Cladius Padi* is a smaller fly than

with fresh material from the latter area, and sprinkle gas-lime on that containing cocoons.

Rose Tortrix (*Lozotania Rosana*).—This little moth varies from 7 to 10 lines across the expanded wings, which are of a brownish-gray, much netted with a darker hue, and having a very distinct patch at the base. The caterpillars are dark olive-green, with white spots, and a brown head. They are but too plentiful everywhere, and feed upon almost every tree and shrub, but are most troublesome to gardeners when they roll up the leaves of Roses, especially those of the unfolding buds from which flowers are expected, but which are crippled beyond remedy if left to take care of themselves. The caterpillars may be found in May and June.

Remedies.—Every good and enthusiastic cultivator knows that he must lose many valuable blooms unless he unrolls the cylinders of leaves and destroys the caterpillars found therein. This is a tedious process, but must be accomplished in the case at least of valuable Roses. The caterpillars are very lively, and let themselves down with a thread on the least suspicion of danger; squeezing the packet of leaves between the finger and thumb before separating them would crush the caterpillar and prevent its escape. On a large scale, and with less valuable Roses, spraying with Paris-green or an infusion of white hellebore, as in the case of the leaf-rolling Rose Sawflies, would save an immense amount of labour, and destroy considerable numbers of the enemy.

Scale Insects.—Several of the most injurious of this family have already been described under the names of Mealy-bug, Peach Scale, Pear Oyster Scale, and others. The life-histories of all are similar, and as the generic and specific differences depend upon minute structural details, it will suffice here to mention a number of common ones injurious to the leaves of various plants. The male is a minute, two-winged fly, seldom seen, and not injurious, because he has no mouth. The females and their larvæ alone are destructive. Orange Scale (*Lecanium hesperidum*) weakens Orange trees and renders the foliage black and filthy if allowed to get established. Camellia Scale (*Aspidiotus Camelliæ*) injures Camellias in a similar way. Another insect that lives on the same class of plants, as well as upon the leaves of Orchids, is *Pulvinaria camellicola*, a small scale with a long, white waxen tube behind it, beneath which it deposits its eggs, reminding one of the Vine Scale described under BARK ENEMIES. Brown Palm Scale (*Aspidiotus palmarum*) in-

festes Palms and Cycads. Brown Scale of Ferns (*Aspidiotus filicum*) is also very injurious to that class of plants, often adapting itself in shape to the slender stipes of the fronds. All of the above are true scale insects. *Dactylopius destructor*, the Mealy-bug of the Orange, and *D. longifilis*, a Mealy-bug infesting Ferns, belong to the same family, and may be placed in the same category as the above. White Palm Scale (*Cerataphis Lataniæ*) is one of the aphides, and infests Palms and sometimes tropical Orchids. A brown scale infesting many stove plants is *Lecanium hibernaculorum*.

Remedies.—For Oranges, Camellias, Palms, Cycads, and Orchids infested with their respective scales, no remedy is more effective than sponging them with a strong solution of soft soap or Gishurst compound. Dissolve either of these substances in hot water, preferably rain-water, and use it while yet warm, as it loosens and removes all filth as well as scales. A dilution of fir-tree oil may be used if preferred. If the trees are numerous they may be syringed with a soap solution at the rate of $\frac{1}{4}$ lb. to a gallon of water. Kerosene emulsion is a good remedy; to make it, boil $\frac{1}{2}$ lb. of soap in a gallon of water, pour the boiling mixture into 2 gallons of kerosene, and stir it violently with a force-pump for five minutes. When cool, add 9 gallons of cold water to each gallon of the emulsion, and use it in the form of a spray. This may be repeated at intervals of several days at any time, but is valuable in killing the larvæ in spring and early summer. The emulsion should not be applied to Orchids. Ferns should be sponged or cleansed with a brush when it is possible to do so, but when the fronds are delicate, remove and burn the old ones after a new set has been produced, but before the larvæ of the scales have time to get upon the young growths. Pine-apple plants may be treated in the same way as Palms, but attention should mostly be paid to cleansing the suckers when taken off to be rooted; keep them in a house by themselves till the old plants have fruited and are thrown away.

Silver Y Moth (*Plusia gamma*).—The forewings of this common moth are gray, with a violet gloss upon them, and clouded with a darker hue. They measure $1\frac{1}{2}$ inch to nearly $1\frac{3}{4}$ inch in expanse, and are furnished, near the middle, with a silvery mark like a y, by which it may readily be distinguished or identified. The caterpillars are green, with a bluish-green line along the back, some white lines on either side of this, and a yellowish line lower down on

either side. They feed on all sorts of vegetable crops, and abound everywhere over a large area of the globe. There are two broods—one in April and the other from July to September

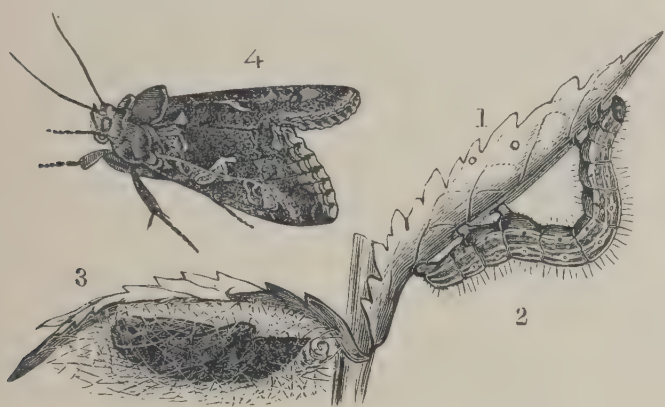


Fig. 115.—Silver Y Moth (*Plusia gamma*).

1. Eggs. 2. Caterpillar. 3. Chrysalis in cocoon. 4. Moth.

inclusive. The silken cocoons are hung up to the food plants.

Remedies.—Clean culture, that is, keeping the ground clear of weeds, especially nettles, is of the first importance. The caterpillars being large and conspicuous, a good plan in the case of many vegetable crops would be to tie some broom or birch branches together, making a light switch or besom with which to beat the plants without injuring the leaves, yet sufficient to knock down the caterpillars, so that they may be trodden by one or two boys following the beater. This could be repeated at intervals of a few days, until no more caterpillars are observable. Looking for and collecting the cocoons would save much mischief later on. Young plants of all the Cabbage tribe, as well as Peas, Beans, and Beet, would be encouraged to grow by drenchings of liquid manure, while the wetting of the foliage would destroy many of the caterpillars. This should be done in moist weather, otherwise the ground should be well moistened with clear water previously.

Slugs and Snails.—There are several very common species of these pests, but none is more widely distributed or more mischievous than the Black Slug (*Limax ater*), which is deeply wrinkled and furnished with a rough shield carried upon the shoulders when crawling. It is often deep-black, but varies to a chestnut hue. The Milky Slug (*L. agrestis*) is whitish or ashy-gray, with black horns and a yellow shield. Like the former, this is very common, and though both are most destructive during spring and autumn when moisture is abundant, yet they are to be dreaded all the year round when moist, mild weather favours their activity. Droughty weather and frost in winter constitute the greatest natural checks to their depreda-

tions. The Garden Snail (*Helix hortensis*) may readily be recognized by its large convoluted shell of a yellowish hue, more or less marbled, and variegated with dark markings. The occupant of the shell comes out when about to travel, and is then seen to be wrinkled and whitish, with a slate-coloured head and back. It is most destructive to plants on and near walls, fences, and palings, where it can find shelter and hiding-places. The Garlic Snail is a name given by gardeners to a small, flattened, slaty-blue or gray species which gives most trouble in hot-houses, especially to Orchids.

Remedies.—Hand-picking is the most effective remedy for slugs and snails of all kinds, notwithstanding the fact of its being a very tedious process. It should be carried on incessantly in spring, when so many tender plants are coming up, or have just been put outside from houses and frames. Naturally the most valuable plants will receive the first and best attention. The early morning and moist evenings are the best times to go collecting slugs. On a large scale, and when time is valuable, dustings of wood-ashes and charcoal-dust will save many plants. In certain cases, such as in plantations of the Brassica tribe, a good sprinkling of salt over the ground when the slugs are out, during moist evenings or mornings, is a good remedy. Equally efficient is strong lime-water spread over the ground with a coarse-rosed watering-pot; this causes the slugs to cast their slimy coating, so that many will crawl away and recover. To prevent this, the remedy should be repeated the same or the following day, before they have time to repair the previous injury, and they will certainly be destroyed. Avoid wetting the plants with strong solutions as much as possible. Traps of Cabbage and Lettuce leaves, as well as pieces of board loosely laid on the soil, will enable the cultivator to secure large numbers of the pest in the vicinity of valuable plants. Rings of wood-ashes, coal, and charcoal-dust, as well as coal-ashes, put round valuable plants, will save them in most cases unless there are slugs already inside the ring. The song-thrush or mavis and blackbird destroy large numbers of slugs and snails, and should be encouraged in and about the garden. When plants in borders are being devoured, apparently without the agency of slugs, search under the leaves of ivy and other climbers upon walls, wooden fences, and under projecting ledges of wood or stone, where snails will in all probability be found hiding during the day, for they feed mostly at night. The Garlic Snail may be trapped with

pieces of Potato, Turnip, and Carrot, but should also be searched for at night with a lantern and destroyed, to prevent it from eating through the young flower-scapes of Orchids, to which it is very partial. Sprinkling salt on the gravel, shells, or coal-ashes on which the pots are stood, will destroy large numbers of the pest.

Slug-worms (*Eriocampa*).—Strictly speaking, these are the caterpillars of a genus of sawflies, so named from their sluggish habits, slimy



Fig. 116.—Slug-worm or Sawfly (*Eriocampa limacina*).

appearance, and from their being thickened behind the head, resembling a small slug lying upon the leaves of their food plants. The Pear Sawfly (*E. limacina*) is black and shining, tinted with violet, and has brownish-yellow legs, the hindmost pair being darker. The wings have dark nerves, and are otherwise often tinted with black. The slimy caterpillars are black and smooth until the last moult, when they become transversely wrinkled and yellowish. They feed upon the upper surface of the leaves of Pears and other trees of the Rose family from the end of July or beginning of August to the beginning of October, when they pass into the ground and lay up for the winter. The leaves they have fed upon turn brown and drop, or holes break out of them. The Rose Slug-worm (*Eriocampa Rosæ*) is another very destructive species. The perfect fly is glossy black, with smoky wings, and the knees, shanks, and feet of the two first pairs of legs white. The caterpillar is yellowish-green with an orange head, and the other characters of the Slug-worm of the Pear. Eggs are laid upon the leaves in May, and soon after the caterpillars commence their work of destruction, feeding for two or three weeks on the upper surface, leaving only a

skeleton, which turns brown; then they pass into the ground and form their cocoons.

Remedies.—The sawflies of the Pear may be looked for in July, seated upon the leaves and depositing eggs. Early in the morning and late at night they are sluggish, and may be shaken down upon a freshly-tarred cloth spread beneath the trees. Hand-picking of the caterpillars may be effected by women and children, and though tedious is effective. The trees may also be dusted with finely-powdered quicklime, which will stick to the slimy coats of the caterpillars; but as they often cast their skin the operation should be repeated the next day to complete their destruction. Strong soap-suds, with a fair proportion of tobacco-water added, is also a good remedy. Provided there are no fruits upon the tree, an infusion of white hellebore, used in the same way as for the Garden Pebble Moth, would be very effective. Paris-green would answer equally well, but if the trees are in fruit, kerosene emulsion should be used instead. It is made by boiling $\frac{1}{2}$ lb. of common soap in a gallon of water, and pouring it in this state into 2 gallons of kerosene; churn it up with a force-pump for about five minutes, and use it as a fine spray when cool, after diluting with 15 gallons of water to 1 gallon of the emulsion. It kills by contact with the caterpillars, and also by their eating it. The cocoons may be destroyed by taking off the upper 4 inches of soil from beneath the trees and burning it, or by pointing in a good dressing of quicklime to the same depth. The perfect insect of the Rose Slug-worm may be looked for in May, and destroyed in the same way as that of the Pear. The other remedies also apply, but if Paris-green is employed, use it at the rate of 1 lb. to 200 gallons of water, and add a little lime to prevent the leaves from being scalded.

Small Ermine Moth (*Hyponomeuta Padellus*).—This tiny moth only measures 7 to 10 lines across the expanded wings, which are white, tinted with gray, or slaty in hue, with four lines of black spots on the front pair. The caterpillars are gray or brown, with black spots, and appear in May and June. They live in large communities under a common web in their younger stages, and when numerous clusters of them are present they sometimes completely destroy all the earlier developed leaves of Apple and Hawthorn trees, turning them brown. When full-fed they form their cocoons upon leaves, especially those that are curled; also upon the stem and similar places where they can find

shelter; and the moth may be found in swarms during July and August.

Remedies.—Keep a sharp look-out for the first appearance of the caterpillars about the middle of May, and before they have had time to

this the trees may be plied with soap-suds from the garden engine, to destroy or drive away the perfect moths.

Snowy Fly (*Aleyrodes vaporariorum*).—This diminutive, white, four-winged fly is closely allied to the aphides and scale-insects, and belongs to the same genus as the Cabbage Powdered-wing (which see), for the habit is precisely similar. It differs from the latter by the absence of spots from the wings. The larvæ infest the leaves of Tomatoes, Cucumbers, Ferns, and other hothouse plants. In less than a fortnight they reach the pupa stage under a small white scale, and in a few more days change to the perfect state, and may be seen in white clouds when disturbed.

Remedies.—Measures must be taken to destroy the pest before the individuals get very numerous, otherwise the leaves of affected plants get filthy with white scales and black with excrement, especially in the case of Tomatoes. Fumigation and frequent syringings with strong soap-suds or tobacco-water will destroy the fly, but has no effect upon the larvæ and pupæ under the scales, so that



Fig. 117.—Small Ermine Moth (*Hyponomeuta Padellus*).

1. Caterpillar. 2. Moth. 3. Larva in web.

destroy the foliage. Syringe the trees with kerosene emulsion as prescribed for Slug-worms, or with Paris-green, at the rate of 1 lb. to 150 gallons of water; but do not forget to add some lime, otherwise the young leaves will get damaged with so strong a solution. Strong soap-suds, though not equally so effective as the above, may be used instead, if preferred, because less dangerous. Apply the solution with a garden engine during the day, when many of the caterpillars are out feeding; drive it with some force into the webs and clusters of the enemy. Many caterpillars will be knocked down, and to prevent their crawling up the trunks again, bands of cart grease or soft soap may be tied round the base of the stem. Should the above remedies have been neglected till the caterpillars and webs have attained some size in June, then a tarred cloth may be spread under the trees and the webs with their contents pulled down, with the hands if convenient, or with a long pole furnished with a hook at the end, in the case of standard trees. Many of the caterpillars will hang suspended from the branches by threads, and must be switched down. Repeat the remedy in a few days, in case any of the enemy may have escaped. Webs and cocoons may be collected about the end of June. After

fresh broods are forthcoming every few days. The tobacco-water, if persisted in, should, however, serve to prevent the females laying their eggs upon the leaves. Kerosene emulsion, made as prescribed for Scale Insects, would be more effective. To 1 gallon of the emulsion add 15 to 20 gallons of water according to the delicacy of the foliage to be operated upon, and use in the form of a light spray to the under surface of the leaves. This should be commenced on the first appearance of the pest, and repeated till the latter is exterminated. Avoid spraying the fruits of Tomatoes as far as possible.

Spittle-fly (*Aphrophora spumaria*).—The perfect fly is of various shades of gray or dull-brown, and has two pairs of wings, the front ones of which are darker in colour, and variously ornamented with brown spots. From its shape and its powers of jumping, it is known as the frog-hopper. The larva is similar in shape but wingless, pale-green and yellow, thin-skinned, tender, and obliged to live under a mass of spittle-like froth of its own making; hence the names of Cuckoo Spit-fly and Froth-fly. In all stages the insect lives by inserting its beak in the leaves and tender parts of plants, sucking the juices of the same, thereby often weakening and injuring them. The larvæ may be found

in early summer, and the perfect fly later on, upon various hard- and soft-wooded plants.

Remedies.—Valuable plants may be cleared of the pest by searching for the larvæ under the spittle with a knife or pointed stick. On a



Fig. 118.—Spittle-fly (*Aphrophora spumaria*).

larger scale the affected plants may be brushed over with a light besom of twigs on bright days, so as to disperse the spittle and expose the tender larvæ to the scorching action of the sun. Syringing the plants afterwards with soap-suds would make the remedy more effective. The perfect insects may be destroyed by boys carrying tarred trays on either side of a row of Chrysanthemums or other plants attacked, while another shakes them to make the enemy jump upon the trays.

Thrips (*Thrips minutissima*).—There are many species of this genus, but that here named, and which infests the Potato and other subjects, may be taken as a type, for the habits of all are the same. It is hardly $\frac{1}{3}$ of a line long, pale-brown, and furnished with four very narrow, strongly-fringed wings; the hinder part of the body is black and shining. The dull-yellow larva is wingless but active, while the pupa is sluggish. All three stages may be found feeding together on the leaves of various plants, which they pierce with their beaks to suck the juices, turning them yellow, or causing them to fall. By the yellow spots and black smears upon leaves their presence may be detected.

Remedies.—Thrips are generally most destructive under glass, and breed there at all seasons, but particularly when the atmosphere of houses is kept in a dry and arid condition for any length of time, or during severe weather, when much firing and too little moisture is employed to counteract the same. Water is inimical to the insects, but they can hardly be dislodged by it after they have obtained a firm footing. By good culture and a proper use of the syringe, and damping down, their ravages in vineries, stoves, ferneries, and similar houses may be prevented.

Indian Azaleas, before being taken indoors in autumn, or at any other time when infested, should be laid on their sides and thoroughly syringed, especially on the under surface of the leaves, with a strong solution of soft soap or Gishurst compound to which some tobacco-juice has been added. Soft-leaved plants, and hairy ones like Gloxinias, must be thoroughly syringed, on the earliest appearance of the thrips, with the above remedies. Fine-foliaged plants, such as Dracænas, Anthuriums, Alocasias, and Palms, should be sponged with either of those solutions or diluted fir-tree oil. Thrips must be dislodged from the leaf-sheaths of Orchids by means of a small brush dipped in one or other of those solutions; but the flowers may be cleared of the pest with a dry brush over the vessel containing the insecticide. Stove and other ferns may be fumigated lightly on two or three successive evenings until the pest has been destroyed. The sponge may be used to great advantage where possible, without damage to the fronds. Autumn and winter are the best times to set about a complete eradication of thrips. When Vines get infested at any time, the leaves must be sponged with solutions of soft soap and sulphur, or Gishurst compound with or without the addition of some tobacco-juice; or the leaves may be wetted and dusted with tobacco-powder. In other cases it may only be possible to syringe the foliage with the above solutions. Out-of-doors, thrips are much less troublesome, except in dry summers, and may be kept in check by syringing with the insecticides already named.

Turnip-fly (*Phyllotreta nemorum*).—In spite of this and several other popular names, the insect is a beetle rather than a fly. It is about a line long, black with a greenish gloss, and has reddish-yellow shanks. The wing-cases have each a yellow band upon them. The Brassy Turnip-fly (*Plectroscelis concinna*) is bronzy or brassy-green, and also common on Turnips, and closely allied to the former, of which there are five or six broods in a season from April to September. The maggots penetrate between the skins of the leaf, where they come to maturity in six days and then pupate in the soil.

Remedies.—Turnips and Beet should be grown in well-tilled and well-manured soil, so that they may grow away rapidly. Water them with weak liquid manure in dry weather, for the beetles are most destructive to the seedlings, especially before they get into the rough leaf. Always sow in lines, so that hoeing and even rolling can be carried on between, for the purpose of destroying the beetles. Tarred

boards between the lines would catch many of the beetles, which have pronounced habits of leaping when disturbed. Keep down all cruciferous weeds which would afford food to the

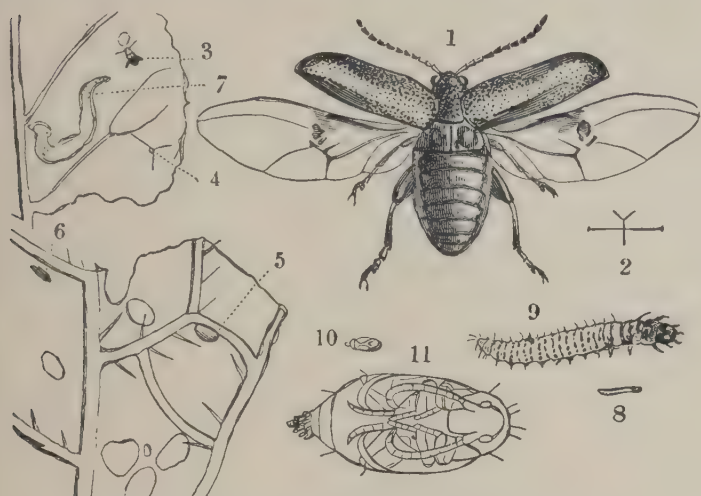


Fig. 119.—The Turnip-fly or Beetle (*Phyllotreta nemorum*).

1 and 2. Insect (natural size and magnified). 3. Insect feeding. 4 and 5. Eggs on under side of leaf. 6 and 7. Maggot advancing in growth. 8 and 9. Maggot full-grown (natural size and magnified). 10 and 11. Pupa (natural size and magnified).

enemy, and trench the ground in winter to destroy pupæ by burying them.

Turnip Sawfly (*Athalia spinarum*).—The perfect fly is bright-orange, and even reddish behind the black head, with four transparent and netted wings. They appear in May or earlier, and the females lay eggs to the number of 200 or 300, in slits made in the edges of the leaves. The caterpillars are hatched out in about five days, and proceed to eat the leaves of Turnips from the edges to the ribs. They are greenish-white at first, but soon become jet-black, and have 6 feet with 14 sucker feet. There are numerous broods in a season.

Remedies.—The caterpillars cast their skins about once a week, and in order to do so they fix themselves to a leaf with their hindmost pair of sucker feet, and then crawl out of the



Fig. 120.—Turnip Sawfly (*Athalia spinarum*).

1. Insect 2. Natural size. 3. Eggs. 4. Caterpillar. 5. Cocoon. 6. Pupa (magnified).

old skin. Should they be disturbed in the operation, they are unable to fix themselves again, and die in the old skin. A boy would

soon exterminate the caterpillars by lightly sweeping over the Turnips once or twice a week with a light broom of slender twigs. The insect in all stages likes dry weather and bright sunshine, but is very torpid on dull or wet days. A good watering from the hose or garden engine would probably destroy large numbers of the caterpillars, but benefit the Turnips, as would weak liquid manure.

Vapourer Moth (*Orgyia antiqua*).—The male of this moth measures $\frac{3}{4}$ inch to $1\frac{1}{2}$ inch across the expanded wings, which are rich-brown. The fore-wings are shaded with a darker hue, and have a small white spot near the hinder angle. The female has a large, brown body, and only rudimentary wings. The



Fig. 121.—Vapourer Moth (*Orgyia antiqua*).

1. Male. 2. Female. 3. Caterpillar.

caterpillar has four brush-like tufts of yellowish hairs on the back, two blackish tufts pointing forwards near the head, and another tuft near the tail pointing backwards. It feeds on Pears, Cherries, Roses, and other woody subjects during June and the three following months, and the perfect moths appear from July to October.

Remedies.—The eggs of this species are laid in dense, but neat and regular masses upon a little bundle of gray silk, like a cocoon, and fastened to one or more dead leaves. These may be found in autumn and winter on various plants, but as the female is almost destitute of wings, she must lay her eggs near the spot where she fed in the caterpillar state. The fallen leaves of trees that were infested in autumn or summer should be carefully raked up and burnt, as well as others in the neighbourhood. The caterpillars are very conspicuous,

and might be hand-picked by women or children having their hands protected with gloves to protect them against the hairs on the caterpillars; or the latter may be swept down on a cloth by means of a light besom and destroyed. They are sometimes in such swarms as to defoliate the trees.

V-Moth (*Halia Wavaria*).—The fore-wings of this moth are pale-gray, with a violet tint, and have four dark markings near the front edge, and the second one unites with a central spot, forming a V. They measure $1\frac{1}{4}$ inch or slightly less in expanse. The pale-green caterpillar appears in May, devouring the leaves of Gooseberries and Currants, and has four wavy, pale-yellow lines on the back and one on each side. It is followed by the perfect insect in July.



Fig. 122.—V-Moth (*Halia Wavaria*).

Remedies.—When the caterpillars of this moth are neither very numerous nor widely extended in a plantation of Gooseberries, women or children may be employed to hand-pick them. It sometimes happens, however, that they completely strip the bushes of foliage. White hellebore and Paris-green would in such cases prove expedient and effective remedies, but being highly poisonous, objection might be taken to them, especially in the case of early Gooseberries intended to be gathered for use in the green state. The blossoms of different species of *Pyrethrum* are ground to powder and sold under the names of Persian insect-powder and buhach. The latter is a Californian product, and is considered the best, but both are good insecticides when obtained pure, and are not poisonous except to insects. Either of the powders named should be obtained from reliable dealers, the infested bushes syringed with water, and then dusted with the insecticide.

Winter Moth (*Cheimatobia Brumata*).—The male of this moth measures slightly over an inch in expanse, and the fore-wings are grayish-brown, with several slender and darker lines across them. The female has only rudimentary wings, and being little else than a bag of eggs, is obliged to crawl up the stems of trees to lay them. This occurs during October, November, and December, intermittingly sometimes, according as the weather is mild and open, or the reverse. The caterpillars are pale-green, or yellowish or clouded, with four slender yellowish-white lines, and commence their depredations

on fruit and other trees as the leaves and flowers are expanding in April and May, and which they forthwith set to devour. Later on they tie a few of the leaves together for the sake of shelter and concealment, from whence they issue forth at intervals to ravage the trees. They are termed “loopers” from their peculiar habit of forming a loop with their body while walking. The most forward of them are full-fed by the end of May, and commence letting themselves down to the ground by a thread, and, burying themselves, remain in the soil till they reach the perfect state in October. They keep ascending the trees from dusk till a late hour in the evening.

Remedies.—The cultivator should aim at keeping the ground beneath the trees perfectly clean, the heads of the trees properly and timely thinned, and the trees themselves at proper distances apart in plantations and orchards, as a preventive measure. The principal and most important remedy is to intercept and catch the females when they commence the ascent of the trees. This is done by putting a band of sticky material round the trunk about a foot from the ground. Nothing is better than good cart-grease plastered rather thickly in bands 6 inch to 9 inch wide, upon broad strips of grease-proof



Fig. 123.—Winter Moth (*Cheimatobia Brumata*).
1. Male moth. 2. Female. 3, 4. Caterpillar (natural size).

paper previously tied to the trees. The paper will prevent injury to the bark, which might happen through the choking-up of interstices, thereby preventing the access of air. This should be commenced at the end of September, and carried on till the end of December, renewing the grease when necessary, and removing the females caught lest others should walk across them as over a bridge. Every five females caught will prevent the laying of a thousand eggs or more. Tar is also useful for the same purpose, but is more dangerous to the health of the trees. Another sticky material some-

times used is birdlime. In any case choose a smooth part of the tree for the band, so that it may fit tightly and so prevent the female moths from crawling through beneath it. At the winter pruning, collect and burn all the rubbish with the view of destroying what eggs may be upon it. Scrape the trunk and branches, clearing them of moss and lichens, which should also be burnt. Watch for the earliest appearance of the caterpillars in spring, and lightly spray the trees (if not actually in bloom) with Paris-green or London-purple at the rate of 1 lb. of either (but preferably Paris-green) to 200 gallons of water kept thoroughly stirred all the time while being applied. A little finely-powdered lime added to the solution would reduce the danger or entirely prevent injury to the tender foliage. The usual prescriptions are 1 lb. of Paris-green to 150 gallons of water for the full-grown leaves of Apples and Pears, 200 gallons for the Plum, and 300 gallons for the Cherry and Peach. Even then some harm to the leafage may result, but the addition of a little lime reduces the risk of scalding to a minimum, even when less water is used than here given. Kerosene emulsion, as prescribed for Slug-worms, may be used instead of Paris-green, but for greater safety 20 gallons of water may be added to each gallon of the prepared emulsion, and used in the form of a fine spray. Soft soap, quassia water, and dilute mixtures of petroleum and water are sometimes used, but they are not very effective after the caterpillars are fourteen days old. When nearly full grown, they may be shaken down upon cloths spread beneath and destroyed. Encourage starlings, titmice, and various other insectivorous birds which feed upon the caterpillars. Ducks, chickens, and other fowls are said to be useful in orchards about the time the caterpillars are full-fed and descending to the ground to pupate. Immediately after the fruit has been gathered, quick- or gas-lime may be scattered over the ground, and forked in to a depth of 3 inches or 4 inches to destroy the pupæ. In orchards, the Strawsoniser may be used to scatter the lime, and again in winter to dust the trees with lime to destroy moss upon the trees as well as the eggs of the moth.

Woodlice.—There are several closely-allied crustaceans, popularly termed woodlice or slaters, which are often very destructive to various kinds of plants, especially when young or in the seedling stage. *Armadilla vulgaris* is smooth, of a dark leaden colour, convex on the back, with seven-jointed horns, and rolls itself up in a ball

when alarmed. *Oniscus asellus* is smooth, grayish-brown, or of a leaden colour, with rows of yellow or buff-coloured spots on the sides and back, and has eight-jointed horns. A third one, *Porcellio scaber*, is of a slaty hue, with seven-jointed

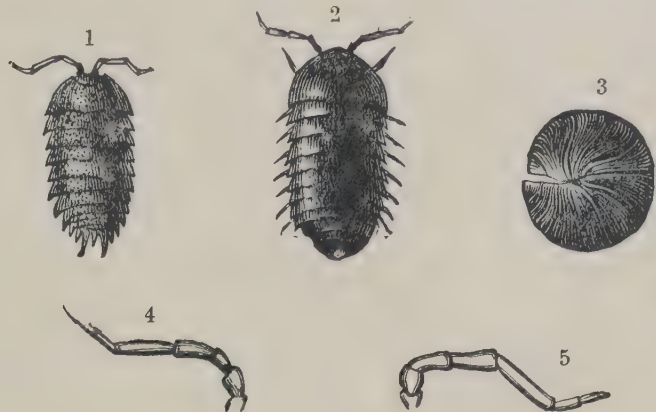


Fig 124.—Woodlice.

1. *Porcellio scaber* (natural size). 2. *Armadilla vulgaris* (natural size). 3. Do. rolled up as a ball. 4. Antennæ of *Porcellio scaber*. 5. Do. of *Armadilla vulgaris*.

horns, and is rough, with small raised points on the back.

Remedies.—Houses and frames are most liable to be infested by woodlice, so that every crack and crevice in the walls and elsewhere should be cemented or stopped up to prevent them finding shelter. Traps may be laid about for them in the shape of pieces of Turnip, Potato, Carrot, or fruit, near the plants to be protected. Hollow stems or pieces of board laid about also act as traps, which should frequently be examined and the enemy destroyed. Valuable plants may be protected by standing them on inverted pots in saucers or vessels of water.

Yellow-tail Moth (*Porthesia auriflua*).—The fore-wings of this moth measure $1\frac{1}{4}$ inch to $1\frac{3}{4}$ inch in expanse, and are satiny-white, with a dark spot near the hinder angle. It has a tuft of yellow hairs at the tail; hence the name. The caterpillars are black, with three small humps on the back, three red stripes along it, and another above the feet on each side. They feed on the Apple and other trees during May and June, and are followed by the perfect insect in August.

Remedies.—As this insect is closely allied to the Brown Tail Moth, the same remedies will answer in both cases.

ROOT ENEMIES.

American Blight.—For description and remedies see under BARK ENEMIES.

Brassy Onion-fly (*Eumerus ceneus*).—The perfect insect is a two-winged fly of an olive-green, with a brassy tint. The body is thickly covered with short hairs; the transparent wings have pitchy nerves, and the shanks are rusty at the

base. The grub is legless, tapering to either end, strongly segmented, covered with short, spiny points, especially towards the tail, which ends in three points, and is of a brownish hue from the slime of Onion bulbs into which it bores.

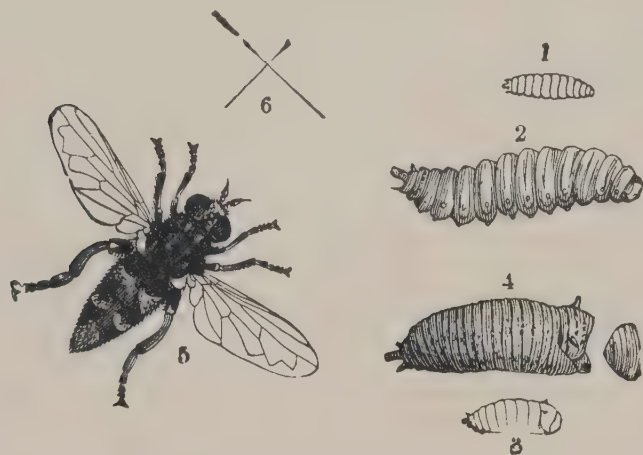


Fig. 125.—Brassy Onion-fly (*Eumerus ceneus*).

1 and 2. Grub (natural size and enlarged). 3 and 4. Pupa (natural size and enlarged). 5 and 6. Insect (enlarged and natural size).

It has also been found in the roots of Cabbages. The pupa hibernates in the bulbs or in soil, and the fly comes forth about the end of April.

Remedies.—Some exemption for the Onion crop has been obtained by dustings or dressings of soot in the early stages of growth, and by good drenchings of lime-water, which is prejudicial to the young grubs, while not injurious to the Onions. The soot, because it contains some ammonia, would also act as a fertilizer, concerning which see under ONION FLY.

Bulb Mite (*Rhizoglyphus Robini*).—This creature belongs to the same class as the well-known and so-called Red Spider, both being truly mites. In this case, however, the oblong or ellipsoid body is colourless, furnished with a few coarse, bristly hairs, and having four pairs of bristly legs, those of the male being longer and better developed than those of the female. To the naked eye of a keen observer, the mites appear like small grains of white sand, but when they are slowly moving about this illusion is soon dispelled. A good lens will show them clearly. Eucharis Mite is perhaps the more common English name, but the species attacks all sorts of bulbs, evergreen and deciduous, as well as various tubers, at all times of the year when the conditions are favourable to its activity. It is generally, if not always, accompanied by the Yeast of Gluten (*Saccharomyces glutinis*), a fungus whose presence may be detected with the naked eye by the red patches on the roots, scales, or neck of the bulbs, as well as by red stripes on the petioles and leaves. These marks are a sure indication of the fungus, and generally of the Bulb Mite as well. The fungus is

believed by many scientific men as well as gardeners to be the real enemy and precursor of the mite, which lives upon the decaying matter of the bulbs. Both are an indication of neglected or unhealthy bulbs, often clearly brought about by errors in cultural treatment.

Remedies.—Prevention is always better than cure, and cultivators should avoid importing infested bulbs to their houses if possible. Bulbs that have been neglected, or kept till reduced to a few healthy scales covered by many dead ones, should be burnt, as they are not worth the trouble of cleaning and resuscitating. When only slightly infested, clear off and burn every infested scrap. Wash the bulbs with sulphur and water, carbolic acid, kerosene emulsion or petroleum emulsion moderately strong, with strong soap-suds or Gishurst Compound to which some sulphur has been added, sulphide of potassium, or with some other well-known and approved insecticide or fungicide. Allow the bulbs to dry, and then repot them in fresh soil, pressing it down very firmly. Some succeed by using peat, others by potting with good, fibrous, and substantial loam. Place the pots in the stove, and when the bulbs begin to grow supply them with plenty of moisture at the root and

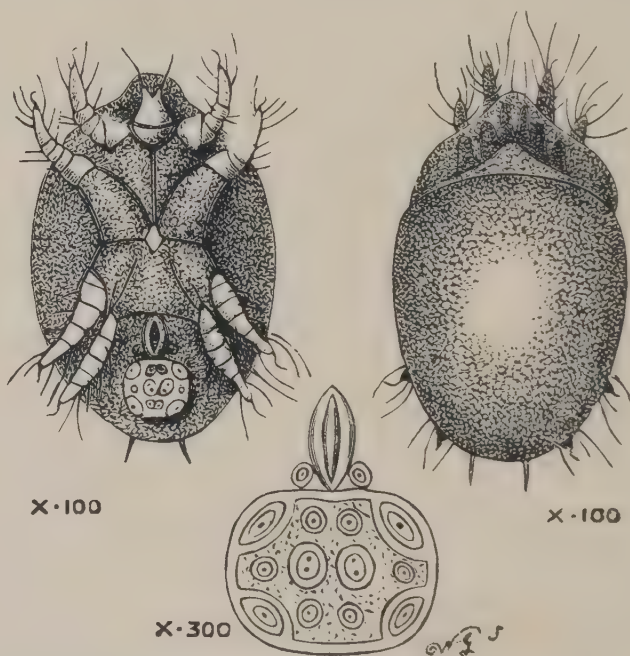


Fig. 126.—Hypopial form of the Bulb Mite. Dorsal and Ventral surfaces. The detached sucker-plate magnified 300 diameters. After Michael.

overhead. Success has often resulted from these methods of treatment. Evergreen species, like the Eucharis, should never be baked till they become dust-dry at the roots. Some successful growers plunge the pots in cocoa-nut fibre in the stove and keep them there all the year round, with excellent results. Others plant the bulbs in beds or narrow borders round the stoves, drawing out the young bulbs, but otherwise leaving the old ones undisturbed for many

years, and literally laugh at the mite. In any case, encourage a healthy vitality in the bulbs.

Cabbage Fly (*Anthomyia Brassicæ*).—This fly has two wings, an ashy-gray hairy body,

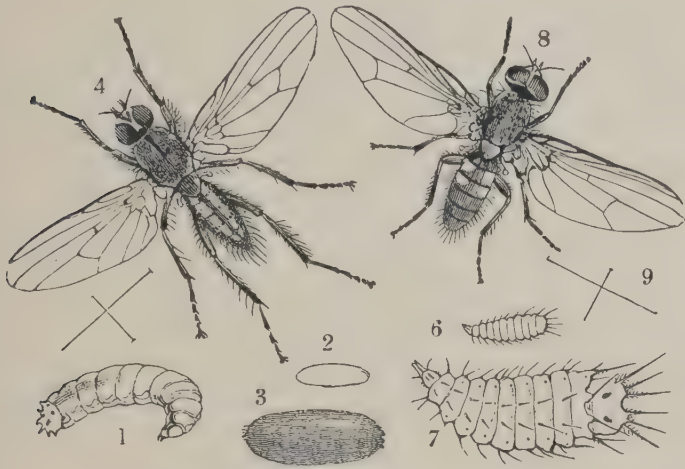


Fig. 127.—Cabbage Fly (*Anthomyia Brassicæ*).

1. Larva of *A. Brassicæ*. 2 and 3. Pupæ (natural size and magnified). 4. *A. radicum* (magnified). 5. Natural size. 6-9. *A. tuberosa*, larva and fly (natural size and magnified).

with three black lines on the shoulders between the wings, and one stripe on the hinder part of the body. The male is much darker. The grub is white, legless, smooth, tapers to a pointed head, and is cut short at the tail-end, where it is furnished with a few tooth-like points on the lower side, and two curious knobs on the flattened end. The pupa is reddish-brown, rests in the soil during winter, and gives rise to the perfect fly in spring, and which produces successional broods till November. The grubs attack the fleshy roots of Turnips, Radishes, Cabbages, Cauliflowers, and others of the tribe, forming hollows on the roots and collar of the plant at or beneath the surface, often causing great damage, and ruining early crops especially. The leaves turn yellow or flag under the influence of sunshine, and the plants die or get broken off with the wind. The Root-eating Fly (*A. radicum*) is closely allied; and its yellowish grubs tunnel the roots of Cabbages, Turnips, Radishes, and other plants. Its pupa is yellowish. Another congener (*A. tuberosa*) bores into the tubers of Potatoes; its grub is bristly with hairs. The first-named is the most common and destructive.

Remedies.—The grubs of the first-named may be destroyed and the crops saved, if taken in hand in good time by well watering the roots with lime-water after being allowed to settle and become clear. Badly-infested plants of little value should be carefully dug up and burnt with the grubs upon them. Valuable, early plants may be saved by drawing away the soil

from the collar and squeezing the grubs with the fingers, then watering them with strong soap-suds, lye of wood ashes, or superphosphate of lime, which would act as fertilizers as well as insecticides. Rotation cropping should be observed, and the ground deeply trenched in winter, which would bury the pupæ of all the three flies if present.

Cabbage Gall Weevil (*Ceutorhynchus sulcicollis*).—The perfect weevil is $1\frac{1}{3}$ inch long, black, and somewhat shining, but thinly covered with gray scales above and densely so beneath. The wing-cases are finely furrowed, and pitted with some tubercles near the end. The head

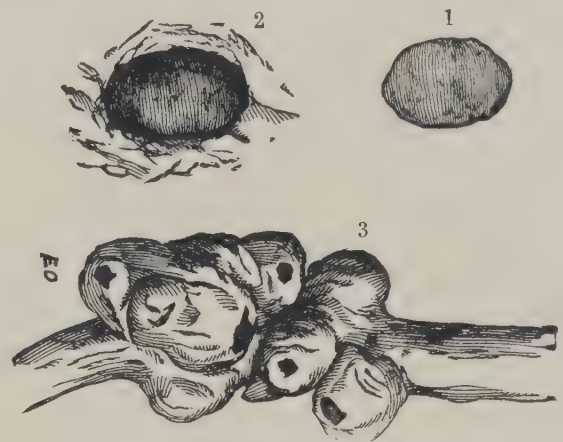


Fig. 128.—Cabbage Gall Weevil (*Ceutorhynchus sulcicollis*).

Earth-case of the larva. 2. Case in its chamber (both magnified). 3. Cabbage root with galls.

is drawn out to a slender curved beak bearing the elbowed horns. The legless, fleshy-white maggots may be found in the centre of galls or small tubers on the main or secondary roots of

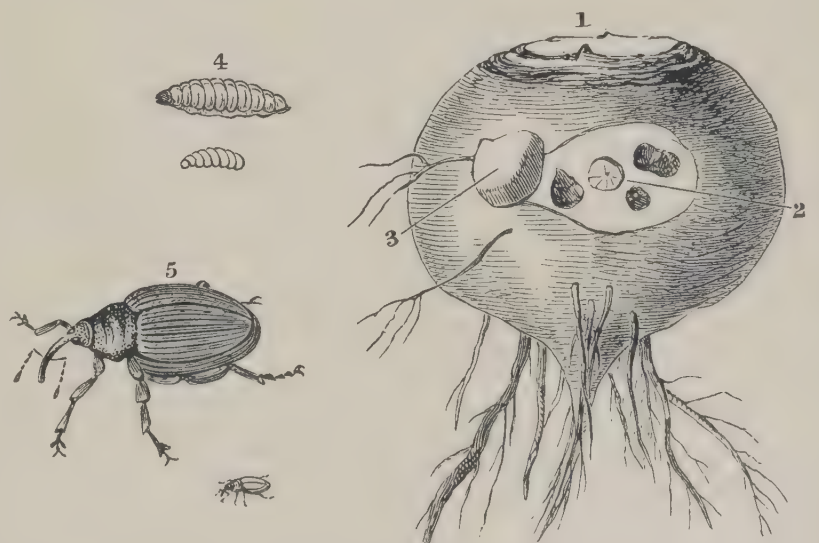


Fig. 129.—Turnip Gall Weevil (*Ceutorhynchus pleurostigma*).

1. Turnip injured by the Turnip Gall Weevil. 2. Excrescences or galls. 3. Ditto opened. 4. Grubs (natural size and magnified) found in them. 5. Weevil (natural size and magnified).

the Cabbage and Turnip at various times of the year.

Remedies.—When young Cabbages are being planted, reject all those having galls upon them, or cut off the same with a sharp knife, and puddle the roots in a mixture of water, clay,

soot, and lime before planting. As soon as the Cabbages are cut, dig up the stems and burn them before the grubs have time to gnaw their way out of the galls. Trench the ground deeply to bury pupæ, and give a good dressing of gas-lime over the top spit when turned down.

Carrot Fly (*Psila Rosæ*).—The perfect insect is a two-winged fly with a shining black body tinted with green, and furnished with a long, pointed ovipositor behind. The head is globular and rusty yellow, while the wings are yellowish,

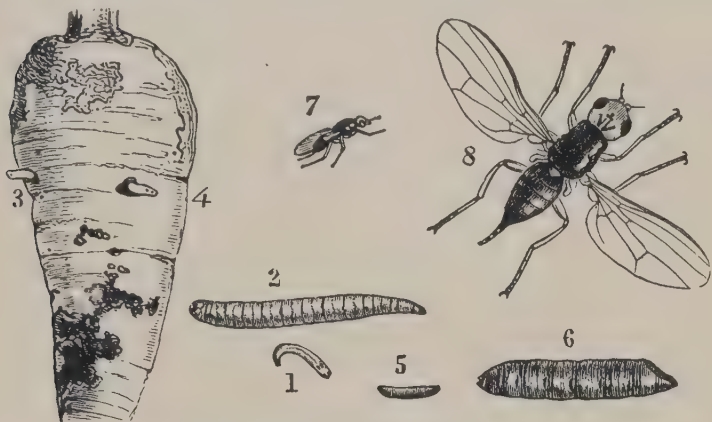


Fig. 130.—Carrot Fly (*Psila Rosæ*).

1. Larva; 2, magnified. 3 and 4. Larvæ appearing from the galleries excavated in the Carrot. 5. Form of pupa; 6, magnified. 7 and 8. The Fly (natural size and magnified).

with ochreous veins. The small maggots are cylindrical, legless, pointed at the head, blunt at the tail, pale shining ochreous and transparent, with a black head. The rusty-yellow pupa lays up in the soil, and in summer hatches out in the course of three or four weeks. There are several broods, and maggots may be found in Carrots left in the ground even in winter.

Remedies.—Good cultivation, by enabling the young plants to make a free and rapid growth from the earliest stages onwards, will often secure a good crop, even in places where the fly may have been troublesome in former times. The ground should be trenched 2 feet deep in winter to bury pupæ which may be in the soil, and allow the roots of the Carrots to penetrate freely and perpendicularly. What manure is given should be placed 15 inches or 18 inches below the surface, and a good dressing of gas-lime should be spread over the top spit after it has been turned into the bottom of the trench. Good crops of Carrots have been taken from rich sandy, and also from peaty soils. In garden cultures, where the soil is of a heavy, clayey nature, great success has accrued by taking out the natural soil to a depth of 2 feet and filling in with peat or leaf mould, sandy loam, or sand, and old potting-bench soil thoroughly mixed. Early Carrots may be sown thinly, and receive no thinning till fit for use, as the loosening of the soil favours insect attack. Main crop, or late

Carrots, on the contrary, should be thinned as soon as they have made a few rough leaves. Good results have been obtained by dressing the ground after the seed is sown with a mixture of wood ashes and petroleum, at the rate of a quart of the latter to a cwt. of the former, and repeating the dressing when the plants are a few inches high. Sand might be employed instead of wood ashes, the object being the even distribution of the petroleum. For this reason kerosene emulsion or petroleum emulsion, because cheaper, might be used to water the plants after thinning them. The emulsion is made by boiling $\frac{1}{2}$ lb. of soap in a gallon of water, and pouring in this state into 2 gallons of either of the oils mentioned, and churning the mixture with a syringe or force-pump for five minutes; to each gallon of the emulsion, which readily mixes, add 20 gallons of water, and when cold run it along the lines of Carrots, avoiding the foliage as much as possible. The emulsion in either case penetrates the soil better than the ordinary article. At the time of sowing, good results have followed from dressings of a gallon of spirits of tar to a barrowful of sand, as in the case of petroleum and wood ashes, also dressings of salt, pigeons' and fowls' dung, quicklime, gas-lime, and soot. All of these should be pointed into the soil before sowing; besides being insecticides, most of them are also fertilizers. Liquid manure and ammoniacal liquor serve the same purpose, and should be applied after the operation of thinning. Good exhibition Carrots may be obtained by making holes 18 inches deep with a dibbler in previously well-prepared soil, and then filling the holes with a compost of sandy loam, wood ashes, pigeons' dung, and sand well mixed together; on the top of this sow a few seeds to be thinned to one when the seedlings grow.

Cattleya Fly (*Isosoma orchidearum* or *I. Cattleyæ*).—This insect belongs to the family of ichneumons, which usually prey upon other insects. It has a black body, hairy shoulders, and four very transparent wings. The female lays her eggs upon the young roots, buds that should develop into pseudo-bulbs, on the flower-stems and flower-buds, and the maggots, when hatched out, penetrate these parts of Cattleyas, causing gouty swellings. The maggots are cylindrical, legless, strongly segmented, and white. As the fly breeds summer and winter in Orchid houses, there are several broods, and one to three of the maggots may be found in each cavity of the swellings. The grubs of a small midge are sometimes found in company

with those of the Cattleya Fly, and there are some doubts as to whether the former is not the real enemy and the latter its parasite.

Remedies.—Drastic as it may seem, the best remedy yet discovered is to cut off the swollen portions of roots, gouty young growths, and also the flower-stems having galls upon them, and burn the same while the maggots are in them. Should the flies be discovered upon the wing, strong tobacco fumigation should be resorted to with the view of preventing the laying of eggs. Pursue these methods till the pest is exterminated, and closely examine every fresh importation from whatever source to guard against fresh infection.

Cockchafer (*Melolontha vulgaris*).—The male of this beetle is about an inch long, with a comb-like process of seven plates at the apex of the horns. The body is black, covered with gray down, and gradually narrowed to a point at the tail end, while the sides are furnished with several triangular white spots of hairs. The wing-cases are reddish-brown. The female is smaller, and the horns have only six plates. She lays her eggs 7 inches or 8 inches below the surface of the soil, and these, when hatched, give rise to large fleshy-white grubs with six legs, a pale-brown head, and a large livid-blue patch at the tail end. They are sluggish, lie in the form of a curve, and take three years to attain full size; all this time they feed upon the roots of grass, fruit-trees, and Roses, sometimes doing serious damage, and always unwelcome in a garden or grass land. The perfect beetle makes its appearance in May or June, flying and feeding by night on the leaves of Apple and other trees, and hanging sluggishly upon them, sometimes in large clusters. May Bug is another popular name of the insect.

Remedies.—Where the beetles abound in garden or orchard, two men should be deputed to inspect the trees about mid-day; one could carry a wide-mouthed sack, while the other fetches down the beetles into it. Tie the mouth of the sack and sink it in a tank to drown the cockchafers, after which they may be given to pigs, which are fond of them. When digging ground infested with this pest, making or renewing grass lawns, or lifting fruit-trees, boys may be employed to collect the grubs as they are dug up. Grass that is being rendered unsightly by the roots being gnawed may be watered with ammoniacal liquor diluted to ten times its bulk with water. During rainy weather, undiluted liquid manure may be freely used. Guano is also a useful fertilizer, and helps to

drive the grubs deeper into the soil. Use it at the rate of 2 cwts. to an acre, 56 lbs. to a quarter of an acre, or 1·4 lb. to the rod. On an extensive scale a water-cart may be employed to distribute the liquids, or the "Strawsoniser" may be used for liquids or solids. Encourage starlings, ducks, and chickens in gardens or orchards, but the latter only where their scratching can be tolerated. Tame gulls, lapwings or pewits, and even the common rook may be kept in gardens by clipping a wing; they destroy grubs largely.

Daddy Long-legs or Crane-flies.—There are several species of gnat familiar under



Fig. 131.—Crane-flies or Daddy Long-legs (*Tipula Oleracea* and *T. paludosa*).

1. Eggs. 2. Maggot. 3. Pupa-case vacated by the gnat of *Tipula Oleracea*. 4. Female of *Tipula paludosa*.

the above names, and *Tipula Oleracea* is one of the commonest and most destructive. It has long, slender ochreous legs, a tawny body with a dusty bloom, and slate-coloured on the back, while the wings are smoky, with yellowish-brown nerves, and longer than the body. The maggots are legless, earthy in colour, about an inch long when full grown, and very tough-skinned; hence the familiar name of Leather-jackets. There are two broods of flies, one in spring, and the other from the beginning of August onwards. The maggots eat the roots of a large number of garden plants, as well as of grass. *T. paludosa* is also very common, especially in wet soils, and is similar to the above, but the wings are shorter, and the back is not slate-coloured. The grubs infest Turnips and Beet. On drier soils a smaller species, named *T. maculosa*, is destructive to Lettuce and Potatoes. The fly is bright-yellow, spotted with black, and has smoky-yellow wings with brown nerves. Other species occur in gardens,

but the maggots are all of the same earthy colour.

Remedies.—Encourage the birds mentioned under COCKCHAFER. Pheasants are known to feed largely upon Leather-jackets. Keep down all weeds, especially in the moist autumn months, that are very favourable to this class of insects. Deep trenching in autumn and early winter is very serviceable in burying the eggs and maggots of the autumn brood, which is usually very numerous. Rank grass in the neighbourhood of gardens should be cut in autumn and burnt; dig all vacant ground. Roll the lawns frequently to destroy grubs. In the case of valuable plants, search for the maggots in the early morning and at night, when they may be found on the surface. Hoe the soil frequently to disturb, kill, and expose the pest to birds. Draw away the soil from the collar of plants, and put a ring of soot, lime, or wood ashes round the stem. Lay traps, as for Wireworms. Assist young plants to make rapid growth by dressings of nitrate of soda and guano, the latter at the rate of 1 cwt. to an acre.

Dart Moths.—There are twenty-three species of dart moths, but two of them are more particularly mischievous in gardens. The Heart-and-Dart Moth (*Agrotis exclamatoris*) measures $1\frac{1}{3}$ inch to $1\frac{1}{2}$ inch, or slightly more across the expanded wings, which are pale-brown, tinted with a reddish hue, and having dark brown or black markings resembling a point of exclamation—a heart and a dart respectively; hence the name. The Common Dart (*A. segetum*) is equally abundant, and more destructive. The fore-wings are grayish-brown in the male, with the club-shaped marking only outlined with black. The female is very much darker,

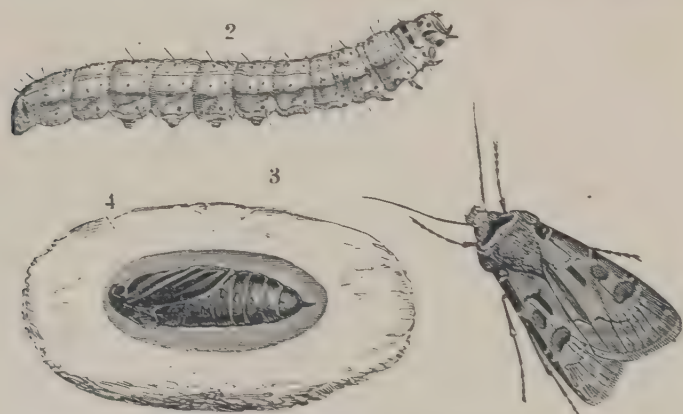


Fig. 132.—The Heart-and-Dart Moth (*Agrotis exclamatoris*).

1. Moth at rest. 2. Caterpillar. 3. Earthen case surrounding chrysalis. 4. Chrysalis.

obscuring the markings. The hinder wings of both species are white. The caterpillars of the two species are closely similar, and dirty-gray with black dots in lines, and thinly hairy.

They abound from September till November, hibernating till May, and sometimes again in the summer months, there being two broods or a succession, for the point is not definitely settled. They are known as surface-grubs, as



Fig. 133.—The Common Dart Moth (*Agrotis segetum*).

1. Moth flying. 2. Caterpillar.

they live in the ground, eating the roots of grasses, vegetables, and flowers, and can travel quickly in quest of fresh food.

Remedies.—The caterpillars remain concealed during the day, and feed at night; hence children may be employed to search for them by day at the roots of infested plants. Hand-picking is even a more successful remedy at night when the enemy is at work. Liquids and powders might then be freely dusted round the roots, including strong soap-suds and tobacco-water, separately or in mixture, also a solution of salt in water, dry soot, or quicklime. Soap-suds is also said to bring them out of their burrows by day, so that they could be collected. Gas-water is another good remedy at night. The Cabbage tribe sometimes recovers when a good handful of soot is put round the roots of each plant before earthing up. Liquid manure and guano and nitrate of soda applied to young plants encourage growth, and often save the crop. Trench the ground in autumn or winter to bury caterpillars and pupæ; and keep the ground clear of weeds at all times.

Field Mice or Voles.—These creatures are remarkable for the shortness of their tails. The Field Mouse or Vole (*Arvicola arvalis*) is about 4 inches long or more, and the tail, 1 inch to $1\frac{1}{2}$ inch in length, ends in a tuft. The back is blackish, and the under side ash-coloured. It frequents fields, especially those that are more or less clothed with a rank foggage of grass, and strays into gardens and pleasure-grounds, where it destroys the grass, barks the stems of various trees in winter, and eats various root-crops, such as Carrots and Turnips. The Bank Vole (*A. riparia*) is bright chestnut-red on the back, but otherwise similar to its con-

gener, and feeds on various garden plants near the banks of streams.

Remedies.—Encourage owls about the premises, and allow them to breed and rear their young. There is no better remedy, for they destroy vermin in incredible numbers. Hawks, kites, jays, magpies, weasels, and stoats, as well as cats, are the natural enemies of this class of pests. It would be dangerous to lay poison about a garden. Field mice are very shy of traps, but deep vessels sunk in the ground frequented by them, greased on the edges and partly filled with water, or holes dug in the soil, and wider at the bottom than the top, will cause large numbers to fall in and so be detained till destroyed. Bank voles can be caught in traps of the ordinary kind, but the perpetual mouse-trap, baited with cheese, will catch large numbers, and requires no setting, but merely emptying.

Garden Chafer (*Phyllopertha horticola*).—This beetle in the larva or grub stage feeds upon the roots of various garden plants and grass. For description and remedies see under LEAF ENEMIES. The remedies prescribed for the Cockchafer under ROOT ENEMIES will also apply here.

Gardenia-root Disease (*Heterodera radicola*).—This troublesome and often fatal disease is caused by a microscopical animal belonging to the order of nematoids. The young animals resemble minute eels. The full-grown male is shorter, stouter, and suddenly narrowed to a point at the tail end. The female, when filled

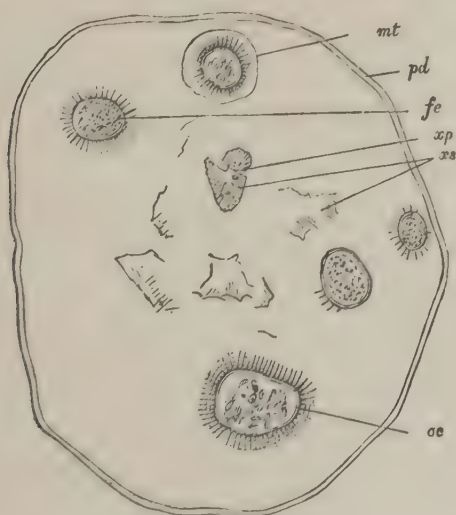


Fig. 134.—Transverse Section of Diseased Gardenia Root.

fe. Immature cysts. oc. Mature cysts with eggs containing young worms. mt. Characteristic morbid tissue. xp. Primary, and xs, secondary wood. pd. Periderm (all magnified 50 times).

with eggs, is shaped like a water-bottle, and entirely fills the cavity of the root where she is found.

Remedies.—This pest comes with infested soil, and sometimes possibly in the water. No

remedy is known that will kill the pest without killing the infected plants. The latter should at once be destroyed by burning, to prevent healthy ones from being attacked if possible.



Fig. 135.—Diseased Roots of Gardenia.

The soil in which it grew should be treated in the same way, and fresh material obtained from a different source for potting purposes. Dilute solutions of permanganate of potassium will, however, destroy any eel-worms that may be in it. Tanks should be emptied and then washed with a similar solution, which is harmless to plant life.

Ghost Swift Moth (*Hepialus Humuli*).—This swift-flying moth measures 2 inches to 2½ inches across the wings. Those of the male are snow-white above, and brownish-black beneath. The female has the fore-wings dull-yellow, with a brick-red border and central spots. The caterpillar is whitish-yellow with a reddish-brown head, and feeds upon the roots of Lettuces, Strawberries, Hop, and various other plants, from August to April, nettles being favourite food. The Common Swift (*H. lupulinus*) is only about half the size, with pale-brown wings and some white streaks. It has similar habits, and feeds on similar plants of a herbaceous kind.

Remedies.—The roots of plants seen to be flagging without apparent cause should be examined, and if the caterpillars are present they may readily be collected and destroyed,

for they are conspicuous on account of their size ($1\frac{1}{2}$ inch to 2 inches long) and easily detected. The burdock and nettle growing in the neighbourhood of gardens should be uprooted to de-



Fig. 136.—Ghost Swift Moth (*Hepialus Humuli*).
1 and 2. Eggs (natural size and magnified). 3. Caterpillar. 4. Chrysalis.
5 and 6. Moths, male and female (natural size).

prive the caterpillars of natural food, and thus prevent their increase in the vicinity of valuable cultivated plants. Rank grass may be cut, to leave no shelter for the perfect moths. The latter may often be caught drowsing during the day amongst shrubs and various garden plants.

Lettuce-root Aphid (*Pemphigus lactuarius*).—The winged female is black, and more or less covered with a bluish-white cottony or waxy matter. The wingless form lives at the roots of Lettuce, and is pale-yellowish, almost white, to the naked eye, and furnished at the tail end with a dense tuft of waxy fibres like the American blight, but different in form. Neither of the forms have honey tubes.

Remedies.—The winged females deposit their young upon Lettuce plants, and these larvæ, being very active, soon run down to the roots, thus spreading the pest at a great rate. All plants which are past their best, or those which have been ruined, should be carefully dug up, roots and all, and burned or thrown into the pig-stye to prevent the aphides from reaching the winged state and flying back to the plants left. Previous to this the Lettuces may be drenched with strong soap-suds containing some tobacco-water to destroy the winged aphides. Plants in good condition should be watered with liquid manure, guano, water, or a solution of nitrate of soda, to make them grow away rapidly; if done in the early stages the crop can often be saved. Watering them with strong

soap-suds, lime-water, or tobacco-water, not too strong, will destroy many of the pest. Soot is also said to be beneficial. As soon as the ground is clear, trench it after giving a good dressing of gas-lime over the top spit. In market gardens the pest is often very destructive, and must be subdued.

Millipedes.—The Flattened Millipede (*Polydesmus complanatus*) has 60 to 70 legs, is flattened on the back, and appears sawed on the edges owing to angles on the segments, and is of a reddish lilac. The snake-millipedes are rounded on the back, and coiled like a snake when at rest. The most common and destructive is *Julus guttatus*, of a pale-yellow hue, with a double row of crimson spots on the back, and having about 170 legs. *J. terrestris* is pitchy black, and shining with a faint row of spots on each side, and has a short spine on the tail. *J. londinensis* is about an inch long, and of a shining dark, lead colour, without a spine on the tail. The centipedes may be classed here. *Lithobius forficatus* is nearly an inch long, is rusty yellowish or brownish, and has 30 legs. Very conspicuous is *Geophilus longicornis*, $2\frac{1}{2}$ inches to 3 inches long, of a bright, clear yellow, very slender, and furnished with 102 to 110 legs. It lives in the ground, and hatches its eggs by coiling itself round them. All feed upon the roots or tubers of various vegetables, such as Potatoes, Turnips, Onions, and Carrots, often destroying those which have been injured

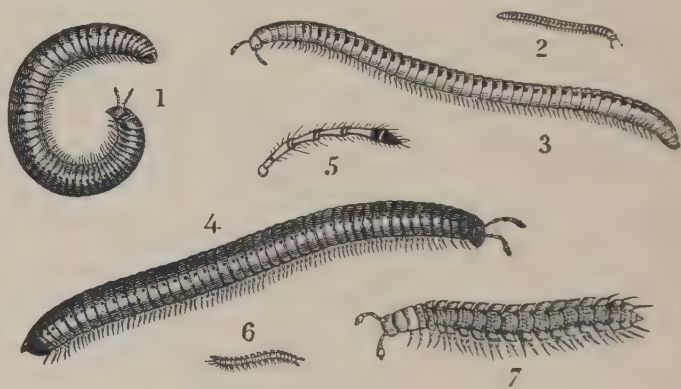


Fig. 137.—Millipedes.
1. *Julus londinensis*. 2 and 3. *J. guttatus* (natural size and magnified). 4. *J. terrestris*; 5, horn (magnified). 6 and 7. *Polydesmus complanatus* (natural size and magnified).

by slugs and wireworms. There are several other species, but all of the same habits as the above.

Remedies.—The most effective remedy is hand-picking, whether in the garden or hot-houses, where they are often present in vast numbers, where moisture is abundant, as in cool Orchid-houses. Salt, soot, lime, and nitrate of soda scattered upon ground infested by them will kill or drive them away. Lime-water would penetrate the soil, and prove more or less

effective. Traps of Cabbage leaves and baskets of damp moss would lure many, and enable them to be collected.

Mole-cricket (*Gryllotalpa vulgaris*).—This insect is $2\frac{1}{2}$ inches long, and is of a velvety-brown above, and yellowish beneath. It has two bristly tails, a shield-like process on the shoulders, short wing-cases, and membranous wings $2\frac{1}{2}$ inches in expanse. The first pair of legs are short, very stout, and furnished with claws like those of the mole; hence the name. The larvæ have no wings. It is only found in the south of England, and has horny jaws, with which it destroys the roots of many plants, including Peas, Beans, and other vegetables, as well as grass on lawns, all of which turn yellow and die. It may also be detected by the little heaps of earth which it throws up. Besides eating vegetables, Mole-crickets devour worms, caterpillars and other insects, and one another.

Remedies.—Trapping is the most effective method of subduing this pest. About September, dig holes in the grass or soil about 3 feet deep and 1 foot wide, filling them with horse dung. The heat attracts them in large numbers to lay up there, and they may be caught in hundreds by digging up the dung at intervals. Pots may be plunged in the soil 2 inches or 3 inches beneath the brim in the haunts of the pest, and many will fall in during their perambulations at night. During dry seasons, fresh turfs may

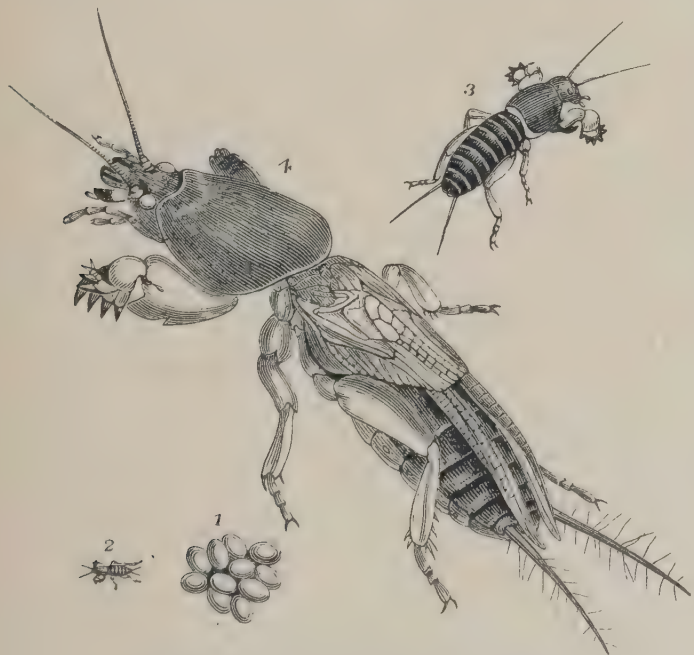


Fig. 138.—Mole-cricket (*Gryllotalpa vulgaris*).

1. Eggs. 2 and 3. Larvæ of different ages. 4. Mature insect.

be laid on lawns, and watered every night; here the crickets will resort, and may be caught in the morning. Dig up burrows, destroying both insects and eggs, in June. The eggs are brownish-yellow, and are laid, to the number of 300 or 400, about 6 inches below the surface.

Narcissus Fly (*Merodon Narcissi*).—This bee-like fly is $6\frac{1}{2}$ lines long, and about an inch in expanse, or slightly over. It is black, with a hairy head, shoulders, legs, and abdomen,

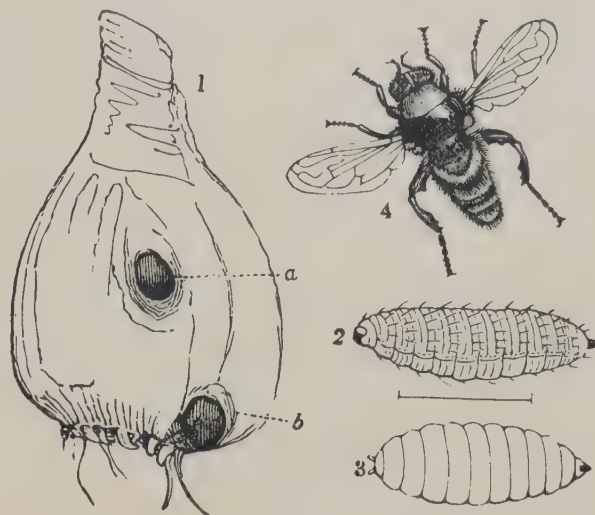


Fig. 139.—Narcissus Fly (*Merodon Narcissi*).

1. Infested bulb; a and b grub-holes. 2. Grub. 3. Pupa. 4. Insect.

the hairs on the latter being yellow. The larva, or maggot, is $\frac{1}{2}$ inch long, legless, and dirty-yellow or brown. When newly hatched it penetrates the centre of the bulb, feeding upon the scales, causing decay, till full-grown, about the end of November, when it passes into the ground, from whence the fly emerges about the end of March, but more plentifully during the next two months.

Remedies.—When planting the bulbs in autumn, affected ones will feel soft and spongy about the neck, and should be destroyed. Earlier in the season, say about August, all suspected bulbs should be submerged in water for seven to ten days, to drown the maggots, which are yet small, and have done but little mischief. The perfect flies may be lured and caught by placing saucers containing strong-smelling molasses about the plantations of *Narcissi*.

Nematoid Worms (*Tylenchus*).—Several species of nematodes, or eel-worms, infest the roots and other parts of various plants in gardens, but their life-histories are but imperfectly known. They are colourless, microscopically small creatures, like eels in miniature, and often do an incredible amount of harm on account of their numbers. Cucumbers are often destroyed by these worms, which penetrate the roots from the soil, causing them to develop swellings, in the cavities of which the pest lives and deposits its eggs, increasing at an alarming rate. A larger species lives in the soft tissues of Carnation leaves, generally near the base, but sometimes higher up. The presence of the worms may be detected by dull or livid patches

on the leaves, the skin of which separates from the soft tissue on both surfaces. Possibly a third species infests Orchids. Sometimes the pseudo-bulbs are destroyed, and in other cases the leaves of *Odontoglossums*, which present the appearance of being covered with brown dust or spores, but which are really pustules containing the eggs, while the eel-worms distribute themselves amongst the inner and softer tissues. Summer and autumn Phloxes often get much infested with nematodes. The stems thicken in places, and get snapped by the wind, especially

when in flower. All are closely allied to the pest which produces the Gardenia-root Disease, and come from the soil through the roots, and may be introduced in the water.

Remedies.—The measures and preventives prescribed for the Gardenia-root Disease apply here. In the case of Carnations and Phloxes, scarce and valuable varieties may be saved by taking cuttings from the healthy shoots and inserting them in fresh soil from a different source; or Carnations may be layered, and the layers removed as soon as rooted, planting them else-

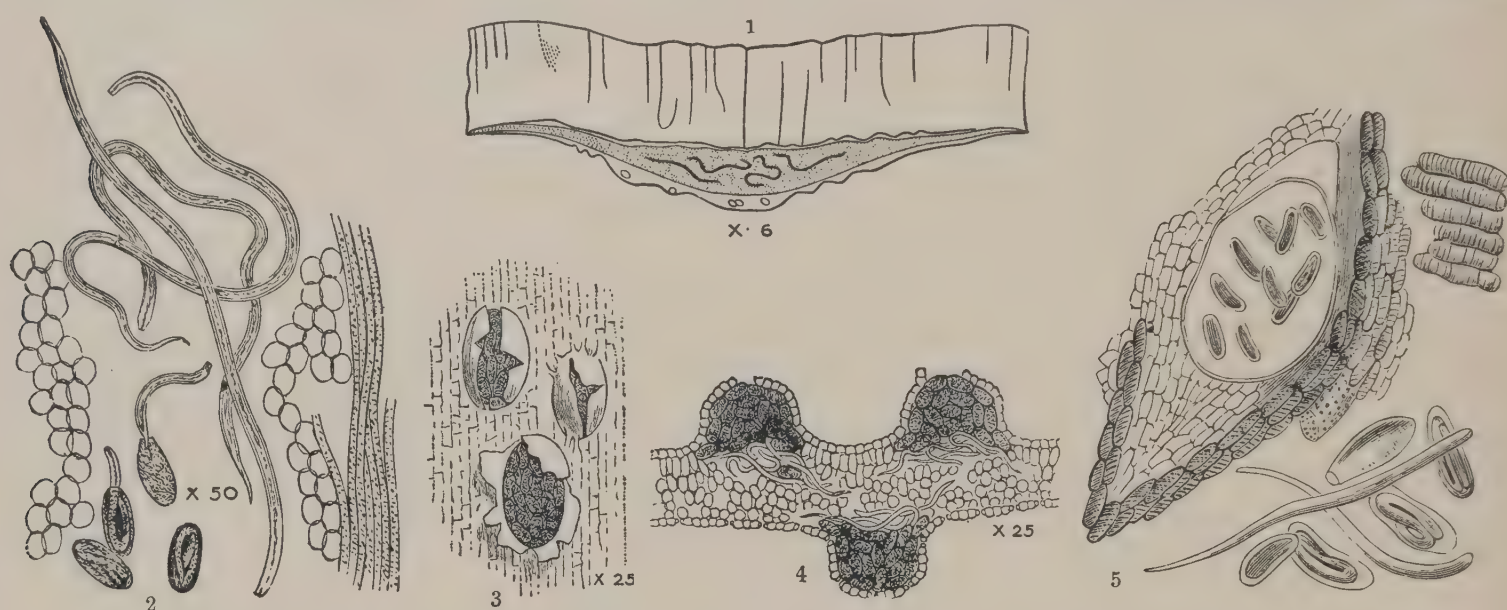


Fig. 140.—Nematoid Worms (*Tylenchus*).

1. Transverse section of Carnation leaf, showing nematoid worms in the tissue. 2. Portion of Carnation leaf (magnified 50 times), showing worms escaping from the eggs and also fully developed. 3. Surface view of leaf of *Oncidium*, showing egg-containing pustules bursting. 4. Transverse section of leaf of *Oncidium*, showing eggs containing worms ready to hatch out in pustules on both surfaces, and worms in the tissues. 5. Portion of root of Cucumber (highly magnified), showing a cyst containing eggs in the centre; also eggs at the lower right-hand corner from which the worms are escaping, and worms that have escaped.

where in fresh ground. The ailment is known amongst gardeners as the gout.

Onion Fly (*Anthomyia ceparum*).—This two-winged insect closely resembles the Cabbage Fly. The male is gray, covered with black hairs, furnished with three dark lines on the shoulders, and a line of spots on the abdomen; the face is white. The female is more of a yellow hue. The maggots are yellowish-white, legless, and penetrate Onion bulbs near the base. There are several broods during the season, and the first lot of maggots commence their work of mischief in May. The pupæ of the last brood hibernate in the soil, but sometimes in the bulbs, till spring.

Remedies.—Active measures for the repression of this fly may be undertaken at various times. When the bulbs are cleared off the ground at the end of summer, all the unsound and useless ones should be carefully collected and burnt, or thrown to the pigs to be trodden amongst the manure. Trench the ground, burying the top spit at the bottom, and scatter a good dressing of gas-lime over it. This would destroy most of the pupæ, and prevent the flies emerging

from the rest. Well-tilled, well-manured ground often enjoys immunity from infestation, even although Onions are grown upon it for many years; but a change every year is safer. A dressing of soot may be given at sowing-time, as well as some fowl or pigeon's dung; after the seedlings are up, alternate waterings with liquid manure, blood manure steeped in water, or guano used in the same way and applied with a coarse-rosed watering-pot, enable the Onions to make rapid growth and escape early attack, which is the most hurtful. Carefully dig up those which turn yellow and burn them, to destroy the early brood of maggots. Watering overhead with soap-suds has also been found useful. Sand saturated with petroleum, scattered broadcast over the soil, and then watered, has also given successful results. Good culture and feeding is, however, the best preventive.

Pot-herb Moth (*Hadena oleracea*).—The fore-wings of this moth are of a dull-red, with a kidney-shaped orange blotch near the middle, and measure about $1\frac{1}{2}$ inch in expanse. The caterpillar is yellowish-brown, with a dark line

on the back, a pale one on either side of this, and a yellow one lower down, making five in all. It appears in August and September, and feeds upon various vegetables, destroying the foliage, and eating through the stems of the Cabbage and others of the tribe, severing the tops from the roots. The pupa hibernates in the soil, and the moth comes out in June.



Fig. 141.—Pot-herb Moth (*Hadena oleracea*).

Remedies.—This moth may be regarded as a general feeder on vegetables of most kinds, and as its habits are similar to those of the Dart Moths, the same remedies will apply in this case.

Red-legged Garden Weevil.—For description and remedies see under LEAF ENEMIES.

Root Aphis (*Trama troglodytes*).—The wingless form of this insect is best known and most troublesome. The body is greenish or yellowish white, transparent, thinly hairy, and more or less furnished with woolly matter behind. The feet are furnished with a double claw, by which it may be distinguished from all other root-feeding aphides. It lives on the roots of a large number of wild plants, and in gardens upon those of the Jerusalem Artichoke and the Auricula. The insect is liable to slight but inconstant variations, and some authorities consider that upon the Auricula as distinct.

Remedies.—Should it prove detrimental at any time to Jerusalem Artichokes, the tubers of the latter should be lifted in autumn and stored, so that the ground could be dressed with gaslime and trenched. Make a fresh plantation on a different piece of ground, and wash the tubers intended for this purpose in strong soap-suds before planting them. When Auriculas get badly infested, they may be turned out of their pots, shaken clear of the soil, and the roots washed clean with a strong solution of soft soap, then with clean water; after they become dry, repot in good, substantial compost, because light material seems to favour the insect. This may be done any time after the plants are out of bloom, up to November. Watering the plants with soap-suds occasionally might keep the pest in check.

Rose-chaffer (*Cetonia aurata*).—This beetle varies from 7 to 10 lines in length, and is golden-green above and coppery beneath. The wing-cases are marked with transverse white spots.

The grubs are fat, hairy, whitish, except at the tail end, which is leaden in hue, and have rusty legs, with a yellowish head, and two rusty, horny spots behind it. They feed on the roots of grass and various garden plants, live for two or three years, and when full-grown are $1\frac{1}{2}$ inch long. The beetle feeds on the flowers of Roses, Strawberries, and other plants, from May till August.

Remedies.—Where the beetles are abundant they may be caught with a bag-net during bright sunshine. They are sluggish in dewy mornings, and again at night, when they may be collected from the flowers and leaves of their food-plants and others in the vicinity, and destroyed by crushing them; or they may for convenience sake be temporarily dropped into a pail of water if very numerous. The remedies prescribed for

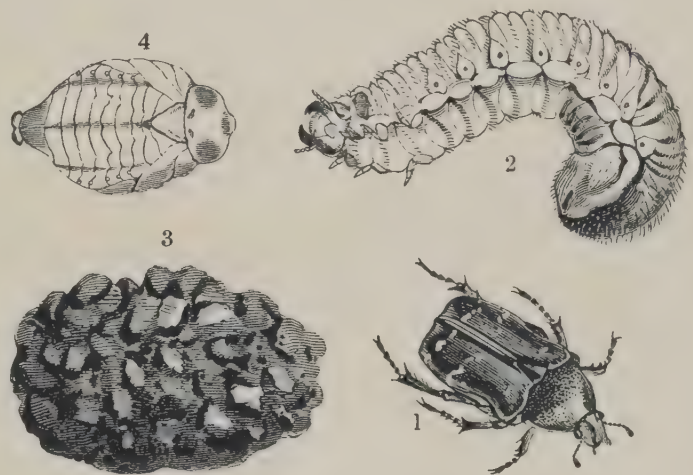


Fig. 142.—Rose-chaffer (*Cetonia aurata*).

1. Beetle. 2. Caterpillar. 3. Cocoon. 4. Pupa.

destroying the grubs of the Cockchafer will also apply to the grubs of the Rose-chaffer.

Summer-chaffer (*Rhizotrogus solstitialis*).—The beetle in this case is 7 to 8 lines long, brown, but reddish-yellow about the shoulders, and clothed with long gray hairs. The wing-cases are pale-yellow, and more thinly hairy, with four raised lines on each. The eggs are laid in the earth, and the fleshy-white grubs are curved like those of the Rose-chaffer, but are smaller, and feed upon the roots of grass and other subjects, doing considerable damage where plentiful. The beetles feed upon the leaves of fruit and other trees during June and July.

Remedies.—The habits of this insect being similar in many respects to those of the Cockchafer, the same remedies apply to both, particularly in the larva or grub state.

Vine Louse (*Phylloxera vastatrix*).—The life cycle of this aphis or plant-louse is complicated, and the attack upon the Vine is commenced according to the particular form of the pest which is first introduced upon it. The true

egg-laying female deposits her eggs upon the roots in autumn, and the aphid hatched in spring is flask-shaped, amber-yellow or rusty, and constitutes the foundress of a colony. She punctures the under surface of the leaf, causing it to grow over her, forming a globular gall, in which she deposits egg-like bodies in hundreds. When

rusty hue. They hibernate in the soil in a dormant condition, but become more active as the temperature rises in spring. Both in Britain (when they do occur) and upon the Continent, the root forms of this louse are by far the most prevalent, and cause the greatest amount of damage. In July some of the insects pass into the pupa state, rise above ground, and develop wings. There are long and short bodied winged forms. In America they spread far and wide in myriads, infesting fresh vineyards.

Remedies.—The gall-producing forms on the leaves may easily be kept in check by pulling off the leaves and burning them as soon as they are seen to be infested. The root forms are most to be dreaded in this country. In very bad cases the Vines may be cut down and burnt at once, or previously have the foliage destroyed by burning sulphur in the house. Then the borders may be thoroughly cleared out, soil and all being taken to a distance from the garden. Thoroughly clean every part of the house, fill the borders with fresh soil, and get another stock of Vines to plant. Methods of cure have, however, been effected by flooding the borders for twenty-five to thirty consecutive days during autumn or winter. Bisulphide of carbon is very effective, according to several authorities who have employed it. The method is to put 2 ozs. of the material into a phial or glass vessel left open at the top and sunk at intervals in the borders, and near the roots of the Vines. The liquid is very volatile but heavy, giving off an offensive odour, which penetrates the soil and kills the insects, but is not injurious to the Vines. The material is poisonous to human life, inflammable, and must neither be spilled nor brought near a fire nor light. Sulpho-carbonate of potassium has also been found efficacious. Another remedy is carbolic acid, mixed at the rate of 1 part to 50 or 100 of water, and poured into holes about 10 inches deep in infested borders. When the Vines are grafted on the roots of varieties of the American Vine, the insect does not increase fast nor do much damage. By adopting some of the above remedies on the first appearance of the attack, gardeners have little to fear, for the louse increases and spreads but slowly, as our climate does not seem very favourable to the production of winged forms.

Wireworms.—These are the larvæ or grubs of beetles belonging to different genera, and numbering nearly seventy species, many of which are rare, while others do not feed on garden crops. Only four of the commonest affecting fields and gardens need be noted here.

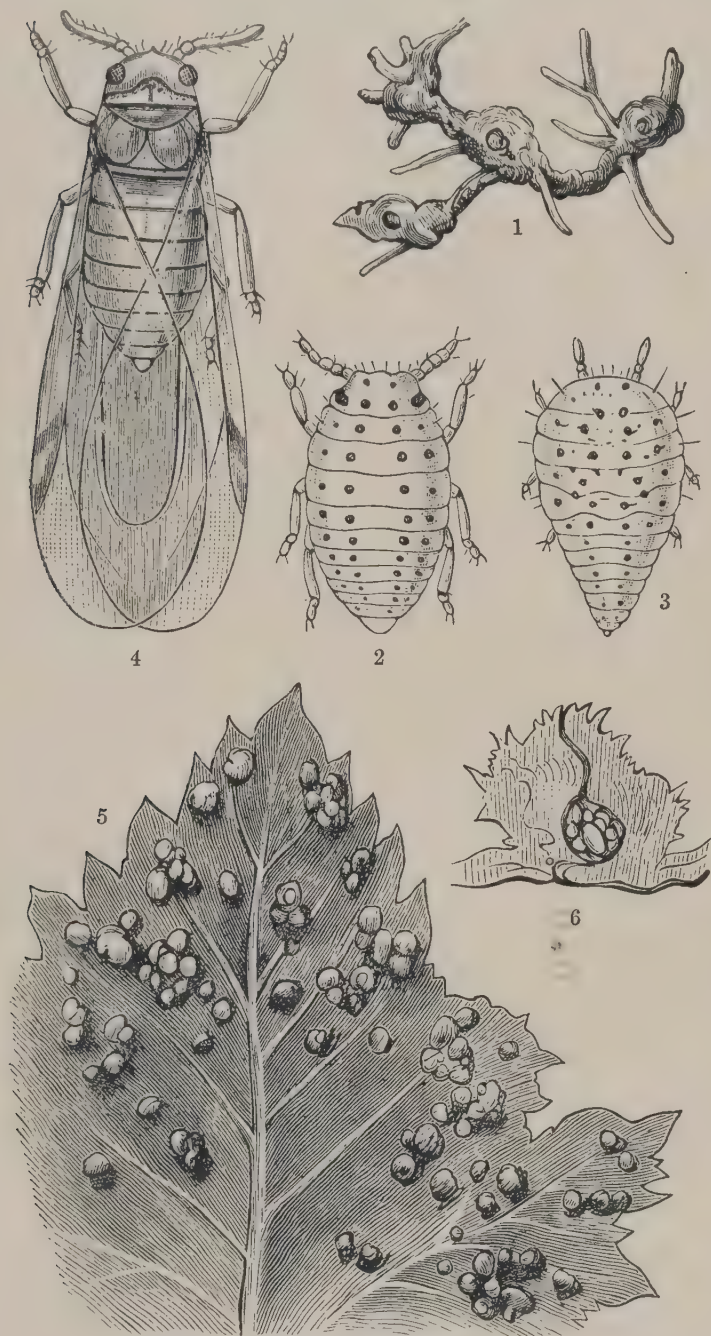


Fig. 143.—Vine Louse (*Phylloxera vastatrix*).

1. Root galls. 2 and 3. Forms of larva. 4. Winged female. 5. Portion of diseased leaf. 6. Enlarged section of excrescence on leaf.

the foundresses are numerous the leaves become studded all over with galls, but more particularly towards the edges. The young from these galls descend to the ground to continue their existence upon the roots, the younger ones of which appear dusted with yellow grains, or develop small tubercles containing lice, while the older roots lose their cortical covering. The root forms of the insect are smaller than the leaf forms, granulated upon the back, and amber-yellow, with an olive tint towards the head and tail. They lay eggs underground. Later generations become more flask-shaped, and of a

The beetles are popularly known as click-beetles, skip-jacks, and similar names referring to the noise they make when leaping off their backs. *Athous hæmorrhoidalis* is dark-brown or black, with paler-brown wing-cases and a reddish abdomen. *Elatér lineatus* has the head and shoulders of a dark-brown, and is covered with

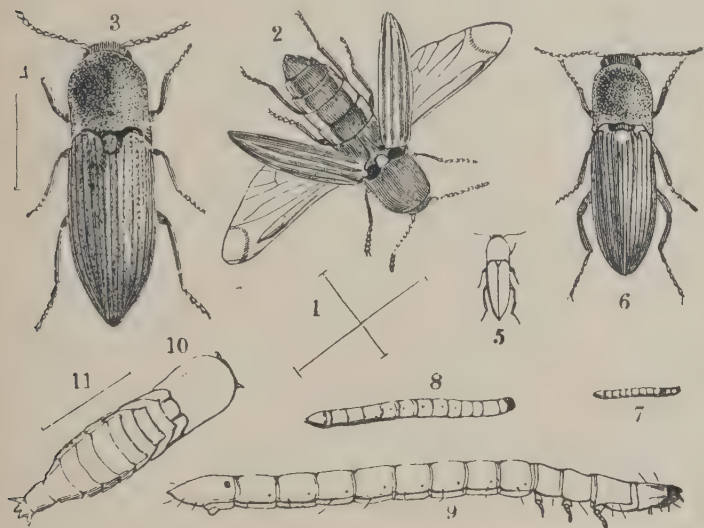


Fig. 144.—Wireworms.

1 and 2. *Elatér lineatus*. 3 and 4. *E. obscurus*. 5 and 6. *E. sputator* (natural size and magnified). 7. Larva of *E. sputator*. 8 and 9. Larva of *E. lineatus* (natural size and magnified). 10. Pupa of wireworm, the natural length being shown by 11.

a gray down. The wing-cases are yellow, closely striped with brown. *A. sputator* is covered with a thick gray down, and having the head and shoulders black. The wing-cases are pale-brown, with a darker tint on the middle. *A. obscurus* is dark-brown with paler wing-cases, and covered with a gray down. The above four species are all very common and destructive. Their larvæ or wireworms are very similar, semi-cylindrical, pale-yellow, hard, wiry, and smooth, with exception of a few scattered hairs. They occur in all soils, but seem to give preference to certain plants, as the gardener but too well knows. They live from three to five years in the wireworm state, then change to pupæ in July or August, but hibernate in the soil till April or May, and some may be found as late as July.

Remedies.—The most effective remedy for ridding the soil of wireworms is to trap them with pieces of Carrot, Potato, Turnip, or other food which they like. Push a pointed stick into these baits, and bury them in the soil about 3 inches deep, examining the same every morning to collect and destroy the wireworms. When the ground is vacant in August dig it deeply and thoroughly break up the clods, for by so doing the pupæ and newly-developed beetles will be largely destroyed, especially the former, as they cannot bear disturbance at this stage. Encourage all insectivorous birds while

such operations are going on. Closely examine all fresh turf brought into the garden, for it often swarms with the pest. Dressings of salt, gas-lime, and petroleum mixed with sand are useful to some extent in driving the grubs deeper into the soil, but neither will kill them unless applied in quantities that would also kill the plants. Various manures help the plants, especially seedlings, but they do not injure the wireworms. In America, at the Cornell University Agricultural Experiment Station, great success was achieved by trapping the adult beetles, and although the species caught were different from the British ones, the experiment is well worth a trial here. The baits used were small bundles of freshly-cut Clover, dough sweetened with sugar, and sliced Potatoes placed in tins and sunk in the soil to the rims. It was proved that the beetles run over the ground in quest of food, but more plentifully at night. The Clover attracted the greatest number of beetles. Another successful method was to poison handfuls of fresh Clover by dipping them in Paris-green water, laying them about the infested ground, and covering them with pieces of board. The beetles were found dead, thus proving that they ate the bait. These remedies should be carried on from April to midsummer in Britain, so that if the beetles are caught before laying their eggs, fresh broods of wireworms would thereby be prevented.

Yellow Underwing Moth (*Triphæna pronuba*).—This moth measures somewhat under, to slightly over, 2 inches in expanse. The fore-

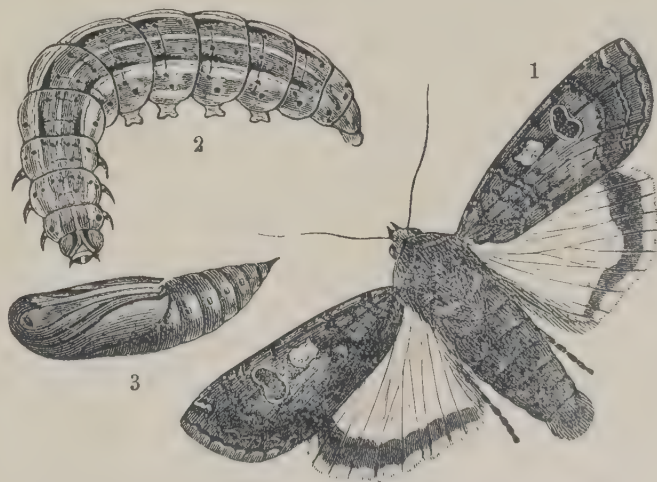


Fig. 145.—Great Yellow Underwing Moth (*Triphæna pronuba*).

1. Moth. 2. Caterpillar. 3. Chrysalis.

wings vary from a pale reddish-yellow to a dark, dull, reddish-brown, with a black spot on the front edge. The hind-wings are yellow, with a black band near the outer margin. The caterpillars are abundant on various vegetables and flowers during April, and are gray or dull-greenish, with three pale lines and some spots

on the back. The moths may be found from June till August.

Remedies.—The habits of the caterpillars, pupæ, and moths are similar to those of the Dart Moths and Pot-herb Moth, so that the same remedies will apply here.

STEM BORERS.

Apple Clear-wing Moth (*Trochilium myopæforme*).—When flying, this moth measures only 8 to 10 lines across the transparent wings, the front pair of which have dark margins and a central spot. The hind-wings have blackish fringes. The body is black, with a red ring on the abdomen. The grub is about $\frac{5}{8}$ inch long, white or pale-brown, from being covered with a dark fluid, thinly hairy, with a shining pale-brown head, and 16 legs, of which the 6 true ones are pale-brown. It feeds beneath the bark of the Apple, in company with the Wœberian Tortrix, during autumn and winter, also in the stems and branches, and the perfect moth comes forth in June and July. The pupa lays up in the stem.

Remedies.—Badly-infested trees present a sickly and diseased appearance, and the bark becomes broken, rough, and dies in places. Such trees have too long been neglected, and being quite useless, should be rooted up and burnt before the end of April, so as to destroy the grubs and pupæ. Other remedies given for the Wœberian Tortrix (see under BARK ENEMIES) will also apply here, and any dressing to the bark should be applied in the beginning of June, and again in July, while the moths are on the wing.

Carnation Maggot (*Hylemyia nigrescens*).—The perfect insect is a dark-brown or black, hairy, two-winged fly, similar, and related to the species which gnaws the roots of Cabbages, and that which bores into the bulbs of Onions. The maggot is cylindrical, tapering to the head, cut short at the tail, round the edge of which are blunt tooth-like processes, with two little knobs tipped with brown on the flattened end; it is also legless, pale-yellow, wrinkled at the sides, and furnished with a horny, black, forked and hooked process serving as jaws, with which it tears its way down the centre of the shoots and stems of Carnations and Pinks, such as Her Majesty. Layers and seedlings in the open border suffer more than indoor plants, and the evil is continued in cold frames if the layers are potted up. The eggs are very often laid apparently on the unexpanded leaves forming

the long central bud of the shoots, for the newly-hatched grub eats through several of them at this stage in trying to penetrate the pith of the shoot; after this it frequently ascends the leaves from 1 to 3 inches in quest of rich food, going down again as the leaves shrivel from the injury. Some cultivators believe that the grub pierces the leaves and goes down them.

Remedies.—Syringing occasionally with soap-suds and tobacco-water from the beginning of August to the end of September might serve to render the plants distasteful to the fly, and prevent the laying of eggs upon them. The presence of the maggot should be looked for before it gets into the shoot if possible, and the affected leaves removed and burnt. If already in the shoot, the crown leaves will readily come away when lightly pulled. The only remedy then is to cut away joint after joint, till solid pith is reached, or the maggot can be pulled out with a pin. It is hopeless to expect the plant to recover, or to check the mischief until the enemy is secured, unless it has passed into the pupa stage. No careful cultivator should delay the remedy till this happens. Shoots already ruined must be burnt, to destroy any maggots that may be in them.

Cattleya Fly.—See description and remedies under ROOT ENEMIES.

Celery-stem Fly (*Piophilæ Apii*).—This insect is as large as the Celery Fly, black, shiny, and thinly clothed with golden-gray hairs. Greater part of the head is chestnut, the veins of the wings yellow, and the legs straw-coloured. The maggot is yellowish-white, and similar in structure to the Carnation Maggot. It penetrates the solid root-stock, or stem, of Celery, working its way up into the leaf-stalks, making burrows, the lacerated surface of which becomes rusty-red, thus destroying the appearance and value of the blanched product. This work of deterioration goes on during winter, especially in mild weather, and in early spring, till the maggot pupates, and the fly comes forth in May.

Remedies.—As in the case of the Carnation Maggot, it is useless to apply insecticides. The only real remedies rest with gardeners and growers, who should carefully collect and burn, or otherwise effectually destroy, all heads or sticks of Celery seen to be infested with the grub when dug up. It may generally be calculated that the grubs are still in the leaf-stalks or stems up to the end of February, so that no infested rubbish should be thrown away nor placed on the refuse-heap, because the grubs.

would pass through their various stages to the perfect fly as if nothing had happened.

Currant Clear-wing Moth (*Trochilium tipuliforme*).—This singular-looking moth measures 9 to 10 lines across the expanded wings, the fore ones of which are transparent, except the margins and a central spot, which are black, tinted with orange. The hind-wings are fringed and very narrow, with the margins similarly coloured. The body is almost wholly black, and the abdomen is engirdled with three yellow rings, with a tuft at the tail end. The grub is whitish, with a pale-brown head, and two spots behind the same. It bores into the shoots of Currant bushes, feeding upon the pith from October to April, when it pupates in the shoot, and the moth comes forth in June.

Remedies.—Shoots that present a sickly appearance in spring when putting forth their leaves (which flag in strong sunshine) should be examined, with a view to determine whether they are hollow. If such is the case, the shoots should be cut away down to the solid portion, and split open, to destroy the grub, or put in a basket to be taken away and burnt. This may



Fig. 146.—Currant Clear-wing Moth (*Trochilium tipuliforme*) and Larva.

be done at the winter pruning when shortening back the shoots, if hollow ones are detected. Burn all the prunings without delay, and other grubs will be destroyed, even though their presence is not detected. They might still be near the tip of the shoots, especially when pruning is done early.

Currant-shoot Moth (*Incurvaria capitella*).—The moth is about $7\frac{1}{2}$ lines across the forewings, which are dark-brown, with a pale-yellow patch about $\frac{1}{3}$ above the base, and two others above the middle. The hinder wings are gray, and all are fringed. The caterpillar feeds in the pith of young shoots of the Red Currant during spring, and probably also in autumn; when full fed it is pale-green, with

a red patch on the back, thinly hairy, and has the head and neck black. The perfect insect appears about the end of May.

Remedies.—Shoots containing a grub betray it by the young leaves withering in April; all

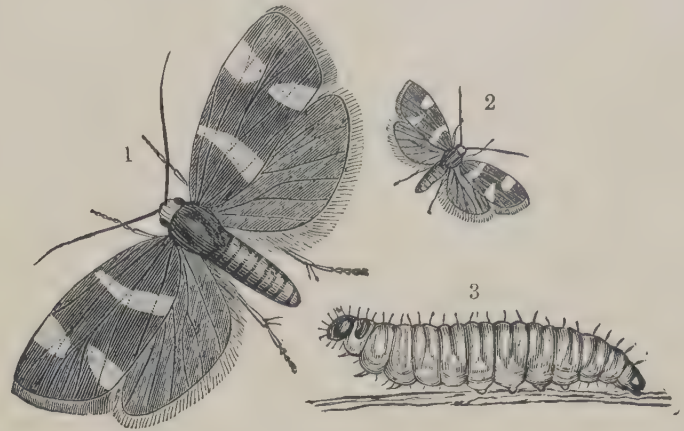


Fig. 147.—Currant-shoot Moth (*Incurvaria capitella*).

1. Moth (magnified). 2. Moth (natural size). 3. Caterpillar (magnified).

such should be cut off immediately, and burnt to destroy the enemy.

Goat Moth (*Cossus ligniperda*).—The moth varies from a little under 3 inches to $3\frac{3}{4}$ inches across the expanded wings, the front ones of which are dusky-brown, shaded with white, and having wavy, transverse lines. It is one of the largest of British moths, and its caterpillar when full grown is 3 inches to 4 inches long. The head of the latter is black, and the back reddish-black, fading at the sides to chestnut-red, and to flesh-colour underneath. It also emits a strong, disagreeable odour, compared to that of a goat, by which it may readily be recognized, independently of its habit of burrowing deeply into the trunks of various fruit and forest trees, making tunnels almost as wide as the little finger. This huge caterpillar lives and feeds upon the wood for three years, but lies inactive during the winter months; it pupates near the mouth of the burrow, and the moth comes forth about the end of June and the beginning of July. Successive broods are reared in the same tree if allowed to proceed unchecked, and their presence is easily detected by the saw-dust-like material ejected from the burrows.

Remedies.—Trees whose stems have become gouty and much eroded with numerous burrows are not worth the trouble of clearing of caterpillars, of which there may be a hundred in a single trunk. They should be cut down, split open, and used as firewood. The big moths are sluggish, and may easily be caught as they rest on the surface of the tree by day. Fine netting or gauze, fastened round the trunk and over the burrows in June and July, would imprison

all the moths as they come out, thus preventing further infection from that source. The caterpillars may sometimes be removed from their

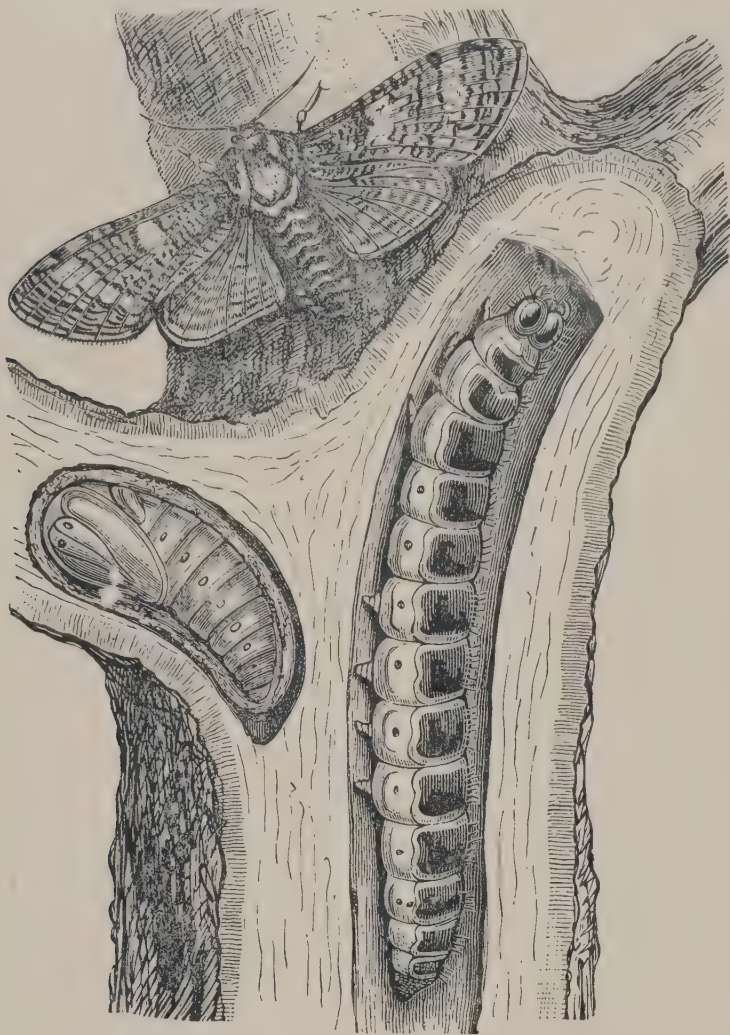


Fig 148.—Goat Moth (*Cossus ligniperda*), Caterpillar, and Pupa (natural size).

burrows in large numbers by means of a wire slightly hooked at the end; others may be crushed by means of wire pushed into the holes. Petroleum, tobacco-water, and soap-suds may be injected by means of the syringe or garden engine, thus destroying many more. A cavity may be formed with clay round the mouth of burrows, and after pouring in some chloroform, the openings should be entirely stopped up with clay to keep in the life-destroying vapour. A mixture of cow-dung and clay, plastered on the tree-trunk, is believed to prevent the female moth from laying her eggs upon it.

Stem-boring Weevils.—There are about eighteen species of snouted beetles, or weevils, named Rhynchites, and natives of Britain. Most of them are similar in habits, and feed upon fruit and other trees, or live in the fruit in the grub stage. Amongst the more common is *R. conicus*, $1\frac{1}{2}$ line long, and blue-green, with black horns and legs. The wing-cases are striated, with deep punctures along the furrows. *R. Alliarie* differs chiefly by being somewhat pubescent, and having the shoulders closely and finely punctured. The females lay eggs during

May and June on the young shoots of several fruit-trees, and then partly dis sever the same, so that they often hang down, and the leaves wither. The grubs penetrate the shoots, feeding upon the pith, and are small even when full grown, fleshy and white.

Remedies.—Where these weevils abound, a cloth may be spread beneath the infested trees, and the weevils shaken down upon it, collected, and destroyed. In the case of young or dwarf trees, the insects may be shaken down upon tarred trays. Collect and burn all withered and injured shoots with eggs upon them, or grubs in the interior.

Wood Leopard Moth (*Zeuzera Aesculi*).—This moth measures 2 inches to $2\frac{1}{2}$ inches across the expanded wings, which are of a sub-transparent white, beautifully marked with bluish-black spots, the hinder wings being more faintly marked. The caterpillar is yellowish, dotted with small, black, raised spots, and having a few larger patches of the same hue. It lives in the stems and larger branches of Apple, Pear, and other trees, making burrows much wider than itself, and when full grown is $1\frac{1}{2}$ inch long. The moths come forth in July, and proceed to lay their eggs then, or in August, upon the tree-trunks. The caterpillar lives one or two years.

Remedies.—The habits of this insect being



Fig. 149.—Wood Leopard Moth (*Zeuzera Aesculi*). Eggs, larva, pupa, moth.

precisely similar to those of the Goat Moth, the same means of eradicating it may be adopted

[J. F.]

CHAPTER XII.

GARDEN FRIENDS.

SOME cultivators, whether gardeners or amateurs, who have a wholesome dread of the ravages of insect and other plant enemies, but

who have little or no knowledge of entomology, are in the habit of killing every creature that creeps, crawls, runs, or flies. They reason that because they live and breed, it may be, amongst plants, therefore they must feed upon something. Knowing nothing of the history of insects and various other of the lower orders of animals, it never occurs to them to distinguish between carnivorous species and purely vegetable-feeders. There are, of course, exceptional cases of species that are destructive both to animal and vegetable life, such as wasps, earwigs, and certain beetles; and some of the latter occur in tribes or families, the most of whose members are carnivorous or predaceous. Whether such insects are to be classed as friends or foes will depend upon the amount of good or injury respectively which they effect in gardens, and the same calculation and definition will apply equally to all other animals whatsoever.

Bees.—Notwithstanding the tirade occasionally got up on the part of some writers against bees for the injury they cause in fields and gardens, there is a great amount of evidence that they are generally beneficial rather than otherwise by being active agents in the dispersal of pollen, thus ensuring the fertilization or cross-fertilization of a large number of showy, or even useful garden plants, and thereby making fruit and seed more plentiful than if such were left to their own resources. The number of plants that are benefited in this way is too great to admit of naming here, but fruit trees and bushes, and the Cabbage tribe in spring, Raspberries, Sweet-peas, and a host of annuals and perennials in summer, may be mentioned as instances. It is better to study the matter specifically before making adumbrations of praise or blame, and before launching out general accusations upon the results of a few hasty observations. The most important or serious charge that has been brought home to bees is that they pierce the calyx of Broad and Long-pod Beans and Scarlet-runners in order to extract the nectar, thus frustrating the production of a part of the crop. Various garden plants of less importance, such as Salvias, Larkspurs, Comfrey, and other long-tubed flowers, are served in the same way during dry weather. The honey-bee (*Apis mellifica*), and two of the humble-bees (*Bombus terrestris* and *B. lucorum*), are equally blameworthy in this respect. They must be kept out of Orchid houses to prevent the fertilization of the flowers.

Beetles.—The Devil's Coach-horse (*Ocypus olens*), also known as the Fetid Rove-beetle, is

one of the British species belonging to the genus. When full grown it is 11 to 14 lines long, dull, deep-black, very narrow, with a large head and very short wing-cases, but well-developed wings, neatly tucked up under the cases except when flying. Amongst beetles it is a very ferocious



Fig. 150.—Devil's Coach-horse, or Fetid Rove (*Ocypus olens*).

1. Larva, 2. Full-grown beetle on the wing. 3. Head enlarged, showing the powerful jaws.

creature, and preys upon insects utterly regardless of size, and will attack any enemy. With its great jaws it can clip earwigs into pieces, and devour the soft parts with the greatest of ease. If alarmed or molested even with a stick, it will bite at the latter with great ferocity, raising the tail over its head like a scorpion, and discharging a fluid of disgusting odour from two bags at the hinder end, and refuses to run away like most beetles. What Homer said of the Greeks applies very well in this case, namely:

“None turn their backs to mean, ignoble flight,
Slowly they retreat, and e'en retreating fight”.

The larva is active all through life, and differs from the adult merely in being smaller, more shining, and in the absence of wings. It also feeds on insects, and on its own kind if pressed for food. This beetle may be found at any time of the year except May, when it pupates, but is most common in autumn. In spite of its forbidding appearance this is a real friend, and should never be destroyed. The Glow-worm (*Lampyrus noctiluca*) is another friend. The male is brownish-yellow, with well-developed, darker wing-cases and wings; but the female is entirely wingless, and the larva resembles her. It is active, and feeds upon snails by crawling into the shell and devouring the soft parts. The Ground Beetles, with one exception, perhaps, that need not trouble the gardener, are predaceous, and should never be destroyed. The Violet Ground Beetle (*Carabus violaceus*) is a large, very common, and typical example of a family of predaceous land beetles that may very often be found under stones and clods of earth

in field and garden. It is 11 to 13 lines long, and black, with a violet gloss on the edges of the shoulders, and rather coarsely granulated wing-cases. It is easily recognized, and should not on any account be destroyed. There are nineteen to twenty-two species of *Coccinella*, popularly known as Lady-birds, natives of Britain, and two of them are extremely common in gardens. The larvæ feed extensively on aphides, and are real friends. The Two-spotted Lady-bird (*C. bipunctata*) is black with scarlet wing-cases, bearing a black spot on each; and there is a creamy patch on each shoulder. It varies greatly, and the wing-cases may be half-red and

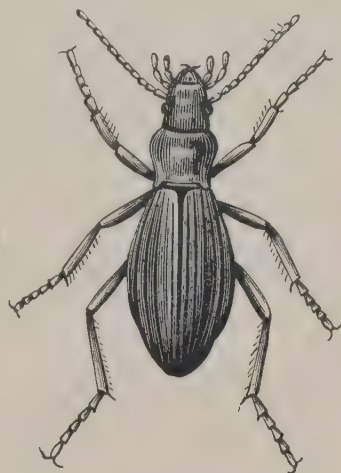


Fig. 151.—Violet Ground Beetle (*Carabus violaceus*).

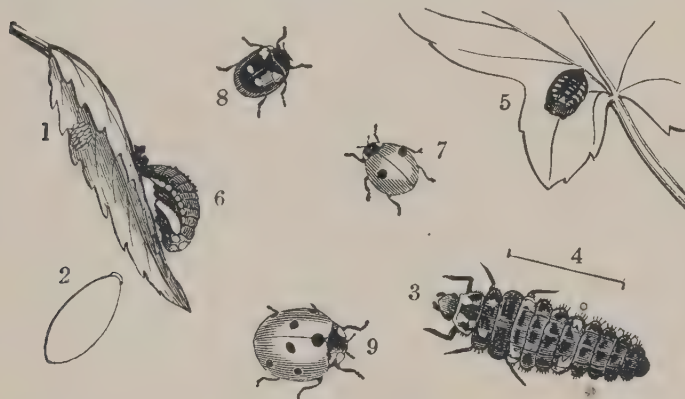


Fig. 152.—Lady-birds.

1. Eggs, natural size, on a leaf. 2. Egg magnified. 3. Larva, with the line 4 showing natural size. 5 and 6. Pupæ. 7. *Coccinella bipunctata*. 8. *C. dispar*. 9. *C. septempunctata*.

half-black, or entirely black. *C. septempunctata* is larger, with seven black spots on the wing-cases. The larvæ are slaty and yellow, with black spots and hairy tubercles down the back, mixed with orange spots. They are very ugly, and like miniature alligators, but should never be disturbed. *Pterostichus madidus* and its allies, to the number of twenty-two species, are very voracious, and feed on a large number of insects, including wire-worms. Some authors divide the group into a number of genera. That under notice is 7 to 8 lines long, and wingless, with black or red legs. *P. cupreus* is another common member of the same family or group, popularly known as Sun Beetles, from the great activity

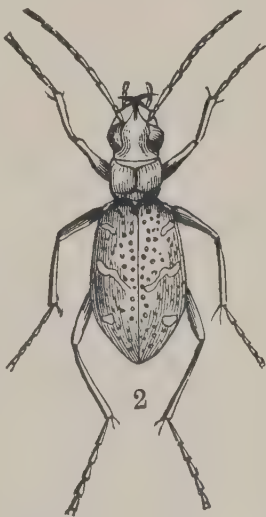


Fig. 153.—Tiger Beetle (*Cicindela sylvatica*).

with which they run to and fro in the sun in quest of food. The last-named is $4\frac{1}{2}$ to 6 lines long, and green, bronzy, brassy, or bluish-black on the upper side, being extremely variable, and black beneath. There are four species of Tiger Beetles (*Cicindela*) in Britain, and the common Tiger (*C. campestris*) inhabits bare banks and sandy commons; it is $\frac{1}{2}$ inch long, and green, with six white spots on each wing-case, including the round one upon the disc. The larva is a curious creature, with a large head and a great hump on its back near the tail, bearing two spines, with which it anchors itself in its burrow, waiting at the entrance for its prey. The perfect beetle hunts for its food, and mounts upon the wing with the rapidity of a bluebottle fly. Its congener (*C. sylvatica*) is larger, black above and violet beneath. The wing-cases have each several creamy-white markings, including a twice-curved one across the middle. Predaceous beetles may generally be recognized by their great activity on the legs or wing, as compared with herbivorous or plant-eating species.

Birds.—A large number of British birds are of indirect utility to man by feeding upon those creatures which prove destructive to cultivated plants of various kinds. These, as far as gardens, parks, and pleasure-grounds are concerned, would consist of such raptorial birds as feed upon mice, voles, and others classed as vermin, and insectivorous birds. Many of the latter, such as the crow family, gallinaceous, and some of the swimming birds, are really omnivorous or general feeders, and whether they are classed as the friends or enemies of cultivation will depend upon the amount of benefit they confer, as compared with the amount of harm they do under varying circumstances. Because some of them pilfer at certain seasons is no reason for wholly condemning them; on the contrary, it would be bad economy to exterminate them. A robin in a vinery where ripe fruit is hanging would generally prove a nuisance and an enemy; but means should simply be adopted for excluding it at that period. Those species whose destructive habits are so notorious as to call for a mitigation of the injury they effect are mentioned under FRUIT AND SEED ENEMIES, as well as the means for protecting fruit and seed crops at their particular season.

Buntings.—There are several British species of this genus, and though they generally feed on grains, they are partly insectivorous during the summer. The Yellow Bunting or Yellow Hammer (*Emberiza citrinella*) is the most common species.

Crows.—There are several species of this group, which, under certain conditions, are of decided advantage in gardens or enclosures. The Common Rook (*Corvus frugilegus*) feeds largely upon wireworms, grubs of the cockchafer, leather-jackets, or the larvæ of Daddy Long-legs, slugs, and the grubs of other insects. It should, therefore, be encouraged within the precincts of pleasure-grounds and gardens. The Jackdaw (*Corvus monedula*) is similarly serviceable, and being very easily tamed, may be kept about the garden, provided it does not prove mischievous. The Chough or Red-legged Crow (*Fregilus graculus*) may be distinguished from the Jackdaw by having red legs. It is confined to the rocky coasts of the south and west, and the Isle of Man, in a wild state, but specimens if procurable may be tamed and kept in the garden. Beetles, grasshoppers, grubs of the fern-chaffer, and various small insects constitute its food, and these it searches for with diligence. The conical or wedge-shaped beak of these birds enables them to dig into the soil for grubs, and the rook uses this power to great advantage. A wing should be clipped to prevent the tamed birds from straying, for a time at least.

Cuckoo (*Cuculus canorus*).—Here we have a summer visitor staying with us from April to July, and young ones sometimes till August. In its feeding it is wholly insectivorous, living chiefly on caterpillars, and the female lays her eggs in the nests of insectivorous birds, such as the Meadow Pipit and the Hedge-sparrow, but sometimes in those of the finches. Gardens and orchards are amongst its favourite haunts, so that it is really a valuable bird.

Finches.—These are essentially granivorous birds, and some of them prove troublesome to seed-beds in spring and other times of scarcity, but may be kept off by netting. The Chaffinch (*Fringilla cœlebs*) feeds largely upon loopers—the caterpillars of certain moths—during summer, and is both common and widely distributed. The Goldfinch (*Carduelis elegans*) is less common, but frequents gardens, and, like the Siskin (*C. spinus*), it feeds largely on the seeds of thistles, ragworts, and other composites, thus helping to prevent the spread of bad weeds.

Fly-catchers.—The two British species, the Spotted (*Muscicapa grisola*) and the Pied Flycatcher (*M. luctuosa*), are not so common as they used and ought to be, for they feed upon insects chiefly, catching them upon the wing. They frequent gardens, especially the first-named.

Gulls.—Two at least of our British gulls are well known for their habits of following the

plough in autumn, winter, and spring, particularly when driven inland through stress of weather at sea. They feed largely on the larvæ known as leather-jackets of Daddy Long-legs and other grubs. One of them at least, the Common Gull (*Larus canus*), is tamable, and often kept in gardens and about homesteads, where it associates with the poultry in winter for the sake of food, but no other liking, as it loves to sojourn by itself in the garden in quest of food during open weather, and delights in the presence of rocks and water. The Black-headed or Laughing Gull (*Larus ridibundus*) is the other common species that often roams inland during the day, and follows the plough in spring. It is a handsome bird in its breeding-plumage, and is probably as readily tamable as its congener.

Hedge-sparrow or Accentor (*Accentor modularis*).—This belongs to the Titmouse family, though of a dull-brown, and unattractive. It frequents hedges and shrubberies about houses and gardens, and builds its nest there, the beautiful bluish-green eggs being known to every school-boy. Its food consists of insects and the smaller members of the snail family.

Lapwing or Pewit (*Vanellus cristatus*).—Every rustic is acquainted with this beautiful bird, which used to be so common all over Britain in the fields, before the inroads of cultivation and the collecting of the eggs for sale, severely thinned its numbers. It feeds upon leather-jackets, wireworms, and similar grubs, consuming about a hundred a day. It is easily tamed, and often kept in gardens to great advantage. A wing should be clipped, as in the case of the gulls, until it gets habituated to its surroundings at least.

Magpie (*Pica melanoleuca*).—Though a shy bird, on account of the persecution it receives from gamekeepers in Britain, it is as readily tamable as the crows, to which it is closely allied, for in Norway the wild birds hop about the doors, and even enter the houses when open, because unmolested. They feed on mice, voles, surface caterpillars, and others, and might be made useful in gardens, if tamed.

Owls.—There are several British species, of which three are common and useful, because mice, voles, or short-tailed field-mice, and young rats constitute their principal food. The White, or Barn Owl (*Strix flammea*) is the most common, and lives in outhouses, holes in rocks, in ivy, and even in the dove-cot, where it has been known to live on friendly terms with the pigeons, neither giving nor receiving molest-

tion. The Long-eared Owl (*Otus vulgaris*) is almost as common as the last, but lives and breeds in trees. The Tawny Owl (*Ulula stridula*) is almost as common, and almost as widely distributed. It lives in hollow trees, holes of rocks, and sometimes in barns. Neither of these should be molested, but allowed to breed, and even encouraged, about homesteads. Some of the smaller and rarer species feed wholly upon beetles, grasshoppers, and similar vermin.

Partridge (*Perdrix cinerea*).—Except in large gardens and pleasure-grounds, this bird will seldom make its appearance; but it is useful, inasmuch as it feeds on grubs, wireworms, and cabbage-gall weevils, as well as grains, and is therefore useful.

Pheasant (*Phasianus colchicus*).—It is gratifying to know that in establishments where this bird is bred largely, it compensates in great measure for any harm it may do in gardens by feeding upon wireworms and leather-jackets. As many as 852 and 1225 of the latter have been taken out of the crops of two birds that were shot in winter.

Poultry.—Such gallinaceous birds as barn-door fowls and turkeys, and also ducks, are general feeders, and prove serviceable in orchards and gardens where they can be tolerated, on account of the large numbers of caterpillars and grubs which they destroy.

Robin (*Erythaca rubecula*).—This familiar bird is a favourite everywhere, and needs no panegyric to recommend it. During summer, and in open weather, it feeds upon insects, larvæ, small slugs, and other vermin.

Starling (*Sturnus vulgaris*).—In summer the starling lives and breeds about homesteads and other buildings where it can find a hiding-place for its nest. It frequents gardens, orchards, and similar places, where it feeds on caterpillars, grubs of chafers, and other insects. During winter it frequents meadows and wet pastures, often in company with lapwings and rooks, and feeds upon wireworms, leather-jackets, and other grubs.

Swallows.—There are five British species of this genus, all of which are incessantly catching insects on the wing, and three of them are partial to the abodes of man and other houses. They are entirely harmless to crops of any kind, and are consequently at peace with every cultivator. The Chimney Swallow (*Hirundo rustica*) and the Martin (*H. urbica*) most frequently come within the range of the garden.

Thrushes.—The Blackbird (*Merula vulgaris*) and the Song Thrush (*Merula musica*) are most

frequent, and the best known in gardens of the seven British thrushes. They feed upon slugs and snails, and even break open the shells of the large garden snail and its allies to get at the unctuous body of the inhabitants. They are so great favourites with everybody, on account of the cheerful and musical character of their song, that the destruction of them should be avoided, notwithstanding their predilection for fruits of various kinds in season. Being also acknowledged as friends in the garden at other times, their inroads against fruits should be prevented by netting the latter.

Titmice.—The Blue (*Parus cæruleus*), the Greater (*P. major*), the Cole (*P. ater*), the Marsh (*P. palustris*), and the Long-tailed Titmouse (*P. caudatus*) should be protected wherever they occur, for they feed upon insects and their larvæ, for which they diligently search on the stems, branches, and buds of trees and bushes. The Marsh Titmouse also devours the seeds of thistles. The Blue Titmouse is the most common and familiar, and perhaps the most frequent in gardens.

Wagtails.—These beautiful birds belong to the same family as the Titmice, but are much larger, and feed upon insects on the ground, including wireworms, as well as various flies upon the wing. They also attend the plough, and feed in meadows amongst sheep and cattle. The Gray Wagtail (*Motacilla boarula*) and the Pied Wagtail (*M. Yarrellii*) are the most common, and would oftenest come within the precincts of gardens, especially in the vicinity of water.

Warblers.—This group is numerous in species, but unfortunately few of them are particularly common in the vicinity of gardens. Where wood and shrubberies are plentiful, the most frequent would be the Black Cap (*Curruc atricapilla*), Greater Pettychaps (*C. hortensis*), and the White Throat (*C. cinerea*). They are sweet singers, very shy, and feed upon insects and their larvæ. The Willow Warbler (*Sylvia trochilus*) and the Chiff-chaff Warbler (*S. hippolais*) frequent trees, and the latter particularly preys upon insects that attack the blossom of trees in orchards. The Sedge Warbler (*Salicaria Phragmites*) is confined to the margins of streams, rivers, and moist places, so that only the gardens near such places would be favoured by it.

Woodpeckers and Tree Creepers.—The bill of these birds is strong, wedge-shaped, and suitable for excavating the trunks of trees in the bark and wood of which grubs and cater-

pillars have taken up their abode. The tongue is also very long, and adapted for fetching out the insects. None of the true woodpeckers are at all common. The Common Creeper (*Certhia familiaris*) is a plentiful and active bird, that climbs from the base to the top of trees, searching the bark with great diligence for insects and their larvæ. The Wren (*Troglodytes europæus*) is well known to everyone, feeds upon insects, and is comparatively harmless to any garden crop. The Nuthatch (*Sitta europea*) is another extremely active tree-climber, and often comes to the ground as well in quest of seeds, nuts, and insects upon which it feeds.

Earthworms.—The most common, the largest, and best-known British species (*Lumbricus terrestris*) is a little-prized and much-slighted creature, and even if regarded as harmless, it is ignored as useless. This is better, however, than an organized raid against a comparatively inoffensive and unaggressive benefactor. The numerous burrows it makes in the soil allows the surface water to pass away quickly, thus constituting a very efficient natural drainage, provided the subsoil is fairly open and not water-logged. The large quantity of soil and humus which it passes through its body in the course of a year, and casts on the surface, constitutes an excellent natural top-dressing, which is particularly beneficial to grass and other dwarf vegetation whose roots are near the surface. The castings are richer in soluble and readily soluble plant-food after passing through the body of the worm than it was previously. When the drainage of pots gets stopped up by worms, means should be taken to evict them by means of clear lime-water, or by turning the plants out of their pots to secure the offenders. Soils excessively infested by worms show that they contain too much humus for the well-being of plants, and will be ameliorated by a dressing of lime. Lawns rendered unsightly and inconvenient on account of the number of castings in spring or autumn, may be watered with brine or a solution of salt and water, or, better still, with lime-water. The worms will rise to the surface, and may be swept up and removed.

Frogs and Toads and Lizards.—The Common Frog (*Rana temporaria*), though formerly, and frequently yet, a much-persecuted animal, is not only harmless, but a great benefactor to all who have in hand the cultivation of the soil. It lives upon various insects and small slugs, and even swallows large, hard-cased beetles and large insects, taking several at a meal. The Common Toad (*Bufo vulgaris*) has been the

innocent victim of even much greater persecution than its near relative, the frog, merely through ignorance, prejudice, and superstition, now happily being dissipated by the light of science. Its food is similar to that of the frog, but it also devours worms, sometimes of large size; it declines to swallow anything not living, and even waits till its victim commences to move as a rule, when the tongue is darted forth in an instant, and the living insect swallowed at a gulp. Large worms entail more deliberation before they are overcome and despatched. The toad can live in drier places than the frog, being mostly terrestrial in habit. Both are now frequently kept in plant-houses, especially where Orchids are grown, to help in keeping down vermin. Small, green, exotic frogs are also very often imported, and find buyers amongst Orchid growers for the same purpose. They take up their station upon a leaf, or upon the beams or supporting bars of the roof, and being out of the way are neither very noticeable nor so likely to be trodden upon as our native representatives of the two tribes above mentioned. The Common Lizard (*Zootoca vivipara*) lives upon dipterous insects, and others of the beetle and grasshopper orders, provided they are not too large.

Hawkflies.—This name is given to a tribe of dipterous or two-winged flies, from their peculiar habit of hovering over wild or cultivated flowers of various kinds, after the manner of a hawk. They are on the wing during spring,



Fig. 154.—Hawkflies.

1. *Scæva balteata*; 2, Larva with greenfly in its jaws; 3, Pupa. 4. *Scæva Pyrastri*; 5, Larva; 6, Pupa. 7. *Scæva Ribesii*.

summer, and autumn, but are generally exceedingly numerous during July, August, and September, in fact much more so than ladybirds or lacewing flies, also avowed enemies of aphides. Besides their habit of hovering, they may also be recognized by the jerky manner of flight, that is, after hovering over some flowers for a time they suddenly dart away for a short distance and then resume their hovering. They

are of various sizes according to the species, but generally have dark-brown or black bodies, variously ornamented with curved yellow spots almost meeting upon the back of the abdomen, or the yellow bands may be continuous, giving the flies the appearance of small wasps, though some of the species are as large as the drone amongst hive-bees, for which they might be mistaken, except by their manner of flight, and by having two instead of four wings. The eggs are laid upon plants amongst colonies of aphides, and the maggots, when hatched, commence feeding upon the helpless aphides, which they seize in their mouth and suck the contents, rejecting only the empty skin. A hungry maggot can thus destroy one hundred aphides in an hour. The maggots may be recognized by their relatively large fleshy and thin-skinned bodies at rest amongst the aphides, or sluggishly crawling about. They are whitish, pale-green, or yellow, and in some cases lined or variegated with orange. When full-fed they fix themselves to a leaf, stem, or other object by the tail, assuming a pear-shaped form while the skin hardens. This is the pupa stage, and the perfect flies emerge in a few days to resume the work of their parents. Neither form should be destroyed if it can be helped, for these hawkflies serve largely to keep the myriads of aphides, including American Blight, in check.

Hornets (*Vespa crabro*).—It is doubtful whether gardeners would care to encourage the increase of this venomous, stinging insect; but it may be some consolation to know, and a plea in their favour, that they live almost entirely upon other insects, including wasps. The hornet is really a large species of wasp, and is most often met with in the south of England, where it makes its nest in outhouses and the hollows of trees.

Ichneumon Flies.—These are legion, and found everywhere over the British Isles. They belong to the same great order as ants, wasps, and bees, and constitute a family of parasites whose function in the economy of nature is to maintain a balance amongst the various insect tribes, while they themselves are often preyed upon by smaller species of the same family. From their habits they are apt to be mistaken for the cause of the disease, due to the attacks of the insects whose larvæ they prey upon. They have four wings, and the abdomen is often almost separated from the rest of the body by a narrow joint or stalk. In form and colour they vary immensely. Some lay their eggs in caterpillars or the pupæ, and the maggots feed

upon the soft but less vital parts of the host until the caterpillar or pupa is about to pass into another stage, when it dies, unable to effect the change. An example of this is shown in Fig. 155, the living caterpillar on the left being covered with a swarm of ichneumon maggots, which destroy it, and its dead body becomes a bed for them in the cocoon stage. Sometimes two to four small brown or black



Fig. 155.—Caterpillar devoured by the Larvæ of Ichneumons, and Caterpillar covered with their Cocoons.

cases, that is, pupæ of some or other of these parasites, will come out of a caterpillar in which the maggots have fed; but in the case of the Large White Cabbage Butterfly, its parasite (*Microgaster glomeratus*) will lay from thirty to sixty or more eggs in the caterpillar. When about full-grown, the latter sickens and refuses to feed, when the maggots gnaw their way out and form clusters upon Cabbage-leaves, where each spins a yellow silken cocoon, generally beside the empty skin of the caterpillar or upon its surface. The caterpillar of the Death's-head Moth does not escape, but is attacked by the largest of the British ichneumons, which lays her egg in the body of the larva, where the maggot hatches, grows to a large size, and finally emerges instead of the moth. Other parasites of this family lay an egg in each aphid they may select, and in which the grub feeds. Aphides attacked in this way become swollen, fixed to the leaves on which they have been feeding, and later on they die in the same position, becoming pale-brown. Thus almost every species of caterpillar, grub, maggot,

aphis, or other form of insect life, has one or more parasites which keep it in check, sometimes with more certain effect, and always with more persistent action, than by human agency. Not even wireworms enjoy immunity. These ichneumon flies, their maggots and pupæ or cocoons, as the case may be, when observed and recognized, should be spared or exempted



Fig. 156.—Ichneumon Flies (magnified).

from destruction where possible to avoid them, while artificial measures are being employed to destroy the caterpillars or other plant enemies. None of the latter attacked by an ichneumon ever reaches the perfect state. No gardener, unless he is specially versed in entomology, can ever hope to recognize or determine the species of parasites that thus befriend him, but he may often, by close observation, obtain conclusive proof that certain insects are parasites by their behaviour during the process of laying their eggs in caterpillars or in aphides. The latter, in some species at least, recognize their enemy, and throwing up the hinder part of their body, sway from side to side as if to cast off the insidious parasite or keep it at bay. In size the grub of the parasite bears some relation to the size of the host in which it has to feed, so that the grub infesting green-fly must be very small. The ichneumon infesting the Death's-head Moth is the largest British species in the family. Scientific men have long recognized the value of parasites in keeping certain insects in subjection, and now transport them long distances, even to the antipodes, where they place the parasites to feed and breed amongst insects that infest fruit plantations.

Lacewing Flies.—There are four genera of these flies, constituting a family of insects whose larvæ are very voracious, devouring aphides in large numbers. It has also been observed that they will attack caterpillars $\frac{3}{4}$ inch long. Some of them are curious-looking creatures, furnished with a row of protuberances along each side, with a tuft of bristly hairs on each tubercle. They vary in colour from whitish to pale-brown, with brown or orange spots. Some cover themselves with the skins of the aphides which they have seized and sucked dry, and others conceal themselves from birds by means of lichens. They are so destructive to the colonies of aphides amongst which they reside that they have been named aphis lions, a title they well deserve, for they never cease

to hunt after and devour the helpless aphides till full-grown, when they change to pupæ and reach the perfect state in three weeks during the summer months, while those that do not attain their full growth till autumn hibernate in the pupa state till spring. The cocoon which the larvæ spin from the tail end is made of extremely tough silk, and varies in size from that of a grain of barley to that of a pea. There are about ten or a dozen British species of *Chrysopa*, and *C. perla* may be taken as a type. The wings are twice the length of the body, pale-green, but giving other beautiful reflections, and finely netted, like a piece of extremely fine lace; hence the name of lacewing flies applied to the group. The eyes are golden-green, very large and conspicuous, so that by them, the characters already given, and the slender, jointed horns equalling the body in length, they may readily be recognized by those even who are not entomologists. They fly chiefly by night, but may often be seen lying lazily upon the

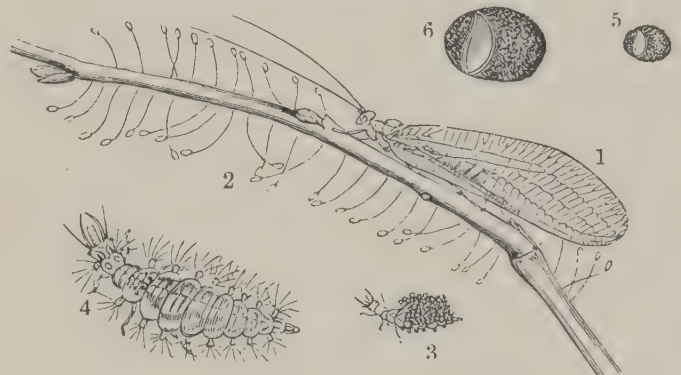


Fig. 157.—Lacewing Fly.

1. *Chrysopa perla*. 2. Eggs. 3. Larva. 4. Larva magnified. 5 and 6. Cocoon (natural size and magnified).

branches of Apples infested with American Blight, and upon other trees, during the day. The female is $\frac{1}{2}$ inch long, and larger than the male. The eggs are laid singly on hair-like stalks in rows or clusters, sometimes projecting an inch from the surface of leaves or branches to which they are attached. Thus the group of lacewing flies may readily be recognized in all stages of their existence, and should be religiously protected as the best friends of man in gardens and orchards. The larvæ may sometimes be found in company with those of the hawkflies and ladybirds, all intent upon the destruction of the aphides.

Slugs.—Some of the more common species of slug have already been described as enemies of cultivation, and such they will ever remain; but there is a genus of slugs that are entirely carnivorous, feeding upon worms, sometimes of considerable size, and also upon the slugs that live upon vegetation, and often prove very

destructive. In the latter respect they are more particularly beneficial to gardeners in promoting the destruction of their enemies. The only British species is the Ear-shelled Slug (*Testacella*

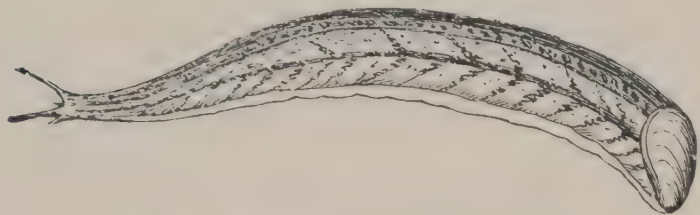


Fig. 158.—Ear-shelled Slug (*Testacella halotidea*).

halotidea), readily distinguishable by a small ear-shaped shell attached to its back, just above the tail. It is also of large size ($2\frac{1}{2}$ inches long when crawling), and deep-yellow, so that by these characters it may readily be recognized by the most casual observer. Usually it occurs most frequently in soil of a heavy, or even clayey, nature, and inclined to be moist. It roams abroad at night when the common slugs are most active on their mischievous errands. During the day it retires into the soil, sometimes to a considerable depth, but often gets turned up by the spade. A foreign species (*T. Maugei*), a native of South Europe, has become established in the neighbourhood of Bristol, and may in time spread over the southern counties at least. It is dark-brown, with a larger shell than that of the native species. No other slugs in this country have a small shell upon their back. Plant cultivators would do well to recognize these two friends of the garden, wherever found.

Spiders.—The British species of spider are very numerous, and to be met with everywhere, but more particularly in summer, and in autumn they are even more abundant. They are wholly carnivorous, and whether in the open air, in plant-houses, outhouses, or dwellings, they must be reckoned amongst the best friends of man. The principal or only objection to them in houses and trimly-kept places is the unsightliness of their webs. Some catch their prey by hunting and speed of foot, or by leaping, others lie in wait, concealing themselves till some unsuspecting fly or other insect comes within their reach, but a large proportion, and the best known of them, construct webs, often of singular beauty and ingenious design, with which to catch their prey. The Red Spider, so called, is not a true spider, and does not come within this category. The most conspicuous, and one of the more common species coming within the range of cultivated plants, is the Garden Spider (*Epeira diademata*), most abundant in September.

The webs are of large size, and suspended perpendicularly from shrubs and bushes by means of strong silken threads, to which the radiating ones, on which the concentric lines are spread, are attached. The owner, when undisturbed, takes up its position in the centre of the web, waiting for victims to become entangled. It is a large spider of a gray hue, beautifully marked with white spots on the back of the globular abdomen, and lives upon small moths and large flies. When not immediately in want of food, it can wind some threads round its victim, thus keeping it quiet, alive, and fresh till wanted. The cocoons are formed in October, and consist of a roundish ball of yellow silk enclosing a flattened mass of eggs, which do not hatch till spring. There is a family



Fig. 159.—*Epiblemum scenicum* (twice natural size).

of leaping spiders that run with great speed, and seize their prey by leaping upon them. One of the most common is *Epiblemum scenicum*, of medium size, oblong in shape, and gray with obliquely transverse white bands on the back of the abdomen and the legs. It may often be noticed hunting about and leaping amongst pots and plants, both under glass and out of doors. Many of the smaller spiders are valuable, inasmuch as they feed upon aphides, devouring large numbers of them. Wherever spiders can be tolerated, they should be left unmolested, as they are perfectly harmless to plants.

Weasel (*Mustela vulgaris*).—This is the smallest animal of its kind, at least in this country, being only $8\frac{1}{2}$ inches to 9 inches long from the nose to the tip of the tail. It is reddish-brown above and white beneath. Its food consists of rats, mice, rabbits, birds of any size, including poultry, or indeed any animal which it can succeed in killing, and to such it is a most formidable enemy. On purely agricultural land, in gardens and orchards, it is truly a friend to cultivators in ridding them of such vermin as rats, mice, and voles. Where lambs are reared and pastured, also on game-preserving estates and in the neighbourhood of the poultry-yard, the owners have a great aversion to the weasel tribe, and wage incessant war against them on account of their destructive habits. In all such cases it would be more satisfactory to encourage owls to take up their residence and breed, even in proximity to gardens and homesteads.

[J. F.]

CHAPTER XIII.

PLANT DISEASES CAUSED BY FUNGI.

KIND OF FOOD REQUIRED BY FUNGI—STRUCTURE AND REPRODUCTION—DIFFERENT MODES OF REPRODUCTION—PREVENTING THE SPREAD OF A DISEASE—PREVENTING A REPETITION OF A DISEASE—FUNGICIDES.

THE knowledge necessary to enable the horticulturist, farmer, or forester to utilize to the fullest extent the discoveries of specialists relating to plant diseases, and also to convey to others an intelligent account of the particular form of disease respecting which information is desired, is: First, familiarity with the general appearance of the commoner fungoid parasites, their varied modes of attack, and the special conditions favouring the same; also the relationship between the different forms assumed by certain parasites during different periods of their existence. Second, acquaintance with the preventive measures which, if acted upon, would prevent the wholesale destruction too often experienced from fungoid diseases. Third, a knowledge of what can be done towards effecting a cure when the disease has revealed itself. In the majority of instances where an annual plant is attacked, cure is practically impossible, and in the case of perennials, the prospect of a profitable crop for that year is slight. In such instances, however, the disease can be arrested in its course, and a recurrence prevented. Hence it follows that a knowledge of the broad principles regulating the mode of life of those fungoid parasites which prove so injurious to cultivated plants should be clearly grasped.

Kind of Food required by Fungi.—Fungi differ from plants possessing green leaves in not being able to obtain their food from the soil, and can only derive nourishment from the bodies of plants or animals, either living or dead.

Those fungi that live on dead vegetable matter, as rotten tree-trunks, roots, leaves, manure, &c., are called *saprophytes*. Certain saprophytes that grow on the ground in woods and pastures might naturally be supposed to obtain their food from the soil in the same manner as the flowers and grass among which they are growing. This, however, is not the case; the roots of such fungi will, on careful examination, be found to spring from fragments of buried wood, roots, &c., or from decaying vegetable humus.

As saprophytic fungi do not injure living plants they may be dismissed without further comment.

On the other hand, those fungi that attack and grow on living plants are called *parasites*. By far the larger number of destructive parasitic fungi are individually very minute, and do not conform to the popular idea of a fungus as represented by a "toadstool", "puff-ball", or the common mushroom, and are only visible to the naked eye when present in immense numbers, as is usually the case, and are then called by such popular names as "rust", "mould", "mildew", "bunt", &c.

Structure and Reproduction of Fungi.—The wide-spread popular opinion that fungi grow very quickly, springing up in a single night, is a mistake. A moment's consideration as to the period of time intervening between the placing of spawn in a mushroom-bed and the appearance of mushrooms ready for the table should be sufficient to disprove such an idea. The mistake is due to considering the part above-ground as representing the entire fungus, whereas the stalk, cap, and gills collectively only represent the seed-bearing portion, corresponding in function to the fruit of a flowering plant, the spawn or *mycelium* as it is properly called, corresponding in use to the root and leaves of a flowering plant, absorbing and assimilating food from the substance in which it is growing. The fruit of the common mushroom first appears as a minute white point on this underground mycelium, and remains underground until its stem, cap, and gills are formed, which requires several weeks to accomplish, when the entire structure is lifted above ground for the purpose of ripening its seed or *spores* as they will henceforth be called, in the air, where they are readily scattered by wind and other agents; these germinate in turn and produce mycelium, which in course of time gives origin to fruit or mushrooms. The same course of development takes place when a living plant is attacked. A spore carried by wind or an insect is deposited on the surface of a living leaf or stem, where it germinates, pierces the skin of the leaf, and enters its tissues; there a branching mycelium is soon formed, obtaining its food from the cells of the plant on which it is parasitic. The mycelium often spreads quickly in the interior of the plant, and not unfrequently every part of the plant contains mycelium before there is any external evidence of its presence. It is well known that a flowering plant must accumulate a certain amount of reserve material from the

soil in which it is growing before it can produce flowers and fruit; in like manner the mycelium of a parasitic fungus does not at once kill the plant in which it is growing, but first accumulates a store of reserve food which enables it to form fruit, when the plant attacked begins to droop. At this stage the fungus bursts through the skin of the diseased plant and forms its fruit on the surface. This is the last stage in the life-cycle of the fungus; it has done its worst, having killed the plant, or at all events certain portions of it, when it produces spores, which if placed under favourable conditions enter another healthy plant and follow the course described above.

Cuttings or portions required for propagation should never be taken from a plant showing disease in any part, as mycelium may be present in those parts that appear to be healthy, and if mycelium is present in cuttings it continues to grow, and the plant is consequently diseased from the first, although it may be some time before any indication of disease is observed.

The terrible sugar-cane disease which at one time threatened to put a stop to the sugar industry in the West Indies was proved to be due mainly to the practice of using for propagation what were considered as healthy portions of canes attacked by a fungus.

For a similar reason the seeds of plants showing a fungous disease in any part should not be sown; neglect of this precaution has in many well-proved instances resulted in disaster; as a case in point may be instanced the "sleeping disease" of Tomatoes, which has been widely spread through using seeds obtained from diseased plants.

Different Modes of Reproduction in Fungi.—Most parasitic fungi possess two, many three or four different modes of reproducing themselves, each one of which answers a definite purpose in the life-cycle of the fungus, and cannot be performed by any of the other methods.

As illustrating the mode of life of a fungus having two different forms of fruit, we may take the too-well-known Rose Mildew (*Sphaerotheca pannosa*). During the spring the leaves of Rose-trees are often more or less covered with a delicate white mould, which at a later period often passes on to the young shoots and flower-buds. Very soon the white mould looks powdery, as if it had been sprinkled with flour. If at this stage of development a minute portion of the mould is placed under a microscope and

magnified about 300 times, it will be seen to consist of numerous slender branches of mycelium, bearing numerous erect chains of spores. When quite ripe these spores become free, and accumulate on the surface of the leaf, giving rise to the powdery appearance mentioned above. This is the summer form of the fungus.



Fig. 160.—Rose Mildew (*Sphaerotheca pannosa*)

1. Summer form of fruit on Rose leaf (natural size). 2. Chains of spores (magnified 250). 3. Single spore germinating (magnified 250). (*Journal Royal Horticultural Society.*)

The moment the spores are ripe they are capable of germination; and being easily blown about by wind, or carried by insects or birds, those that happen to alight on the damp surface of a healthy Rose leaf or young shoot germinate at once, and within a few days give origin to the mould-bearing spores, which are in turn dispersed. This quick method of spore production continues throughout the summer months, and as successive crops of spores are produced in immense numbers in rapid succession, it can be readily seen how easy it is for a disease to spread when it has once appeared. As a rule an epidemic is always due to the spread of the summer form of fruit; in fact its one use is to enable the fungus to extend its geographical range, and where a considerable number of plants of the same kind are grown in close proximity, this function is generally exercised to the utmost, unless special precautions are taken to prevent it.

During early summer the diseased leaves curl and fall, producing only the summer fruit of the fungus, but the diseased patches on the young shoots and fruit continue to grow, forming quite conspicuous white velvety tufts, which later in the season produce a second form of fruit called winter fruit. This second form of fruit is much more complicated in structure

than the summer form, appearing to the naked eye as very minute black points, half buried in the white felty mycelium.

The use of winter fruit to the fungus is very different to that of the summer fruit. The



Fig. 161.—Rose Mildew.

1. Winter form of fruit on Rose hip (natural size). 2. A single fruit with its appendages (magnified 200). 3. Spores produced in the winter fruit (magnified 350). 4. A single spore germinating (magnified 350). (*Journal Royal Horticultural Society.*)

spores of winter fruit will not germinate at once when ripe, but only after a period of rest. The winter fruit of the Rose Mildew may remain on the shoots all winter, or may fall to the ground, and the part of the Rose on which it grew may completely decay, but the winter fruit does not decay, but remains lying on the ground, and the following spring, just when the young Rose leaves are expanding, the spores of the winter fruit of the fungus are set free and blown about by wind, and those that happen to alight on the damp leaves of Rose-trees germinate, enter the tissues of the leaf, and soon give origin to the summer form of the fungus.

The use of winter fruit is to continue the fungus from one generation to another and, by its power of remaining for some time before it can germinate, to tide the fungus over that period of the year when the plant on which it is parasitic is also in a resting condition.

The life-history of fungous parasites, as explained above, must be clearly understood before the prevention of a disease can be carried out on scientific principles, and with any hope of success. The course to be followed resolves itself into two distinct parts.

1. Preventing the Spread of a Disease.

—Parasitic fungi, as a rule, do not attack in-

discriminately every living plant that their spores happen to alight on, but are confined to a single kind, or at most to plants that are botanically closely related.

An epidemic or extensive wave of disease can only occur where large numbers of the same kind of plant are growing in close proximity, as a field of corn or Potatoes, or a house crowded with Tomatoes, Chrysanthemums, &c. Of course it is impossible to alter the manner of growing field-crops, but it is doubtful whether it is wise to crowd plants of one kind in houses. At all events it must ever be borne in mind that crowding plants of the same kind favours the spread of disease.

If a disease shows itself, the affected plants should be removed at once—an operation too frequently neglected—and the remainder of the plants sprayed without delay. Spraying will not cure a disease, but if properly and promptly done, it will prevent the spread of a disease by destroying all spores that may have been deposited on the leaves of healthy plants; and furthermore, as the fungicide or liquid used for spraying adheres for some time to the surface of the leaves, it destroys all spores that alight on the leaves before they germinate and enter the tissues. Spraying therefore is purely a preventive measure, but none the less valuable



Fig. 162.—Apple-tree Canker (*Nectria ditissima*).

Branches of an Apple tree showing the bark destroyed by the fungus. The little white points in the cracks on the diseased parts are the fruits of the fungus, which are of a bright-red colour (natural size). (*Gard. Chron.*)

on that account, for “prevention is better than cure”, and also much easier to accomplish.

2. Preventing a Repetition of a

Disease.—After the diseased leaves and flowers have fallen the Rose-tree is perfectly free from disease, and would remain so unless a fresh inoculation of the leaves occurred the following season. This would depend entirely on the presence of winter fruit of the fungus in the vicinity of the Rose-tree, and such must necessarily have been produced the previous season; hence it is of primary importance in every instance where a disease has previously existed, that all parts of diseased plants, leaves, fruit, &c., should be collected and *burned*—not thrown on a rubbish-heap—otherwise the winter fruit present on such will in all probability give origin to the disease afresh the next season. Diseased plants should not simply be placed in some out-of-the-way place and forgotten, and thus allow the spores to diffuse, but should be destroyed; or, if valuable, all diseased parts should be removed and the plant sprayed with a fungicide. Success in keeping plants free from fungous diseases depends much more in carrying into effect a few simple rules, as stated above, than in possessing a profound knowledge of fungi, and perhaps the most important point is that of never neglecting to check a disease on its first appearance. Half-measures always end in disaster.

The above remarks do not apply to Rose Mildew only, but are of universal application.

A second type of fungi included under the popular name of "mould", and known botanically as *Sclerotinia*, proves very destructive to Lilies, Crocuses, Snowdrops, and bulbous plants in general; while another section of the same group destroys Cucumbers, Melons, Scarlet-runners, Potatoes, &c. The members of this group possess three distinct methods of reproduction. There is the usual summer form of fruit, which appears under the form of a delicate gray mould, forming small, minute velvety specks on the leaves and flower-buds of Lilies, on the leaves and flower-spathes of Snowdrops, or commences near the ground and spreads up the stems of Potatoes, Chrysanthemums, Melons, and numerous other plants. The mould or summer fruit as usual enables the fungus to spread quickly, the rapidly-formed spores being blown by wind from one plant to another, which in turn become diseased, and form a new centre from which spores are liberated. During the summer the mycelium of the fungus spreads rapidly in the tissues of the diseased plant, in the case of bulbous plants passing into the bulb or permanent portion of the plant, where it forms into small compact lumps, vary-

ing in size from a pin's head to that of a Vetch seed, depending on the particular kind of fungus causing the disease. These lumps are at first white; eventually becoming black outside, and are called *Sclerotia*, and may be found embedded in the outer scales of the bulb, and also in the substance of the stem just above-ground. In

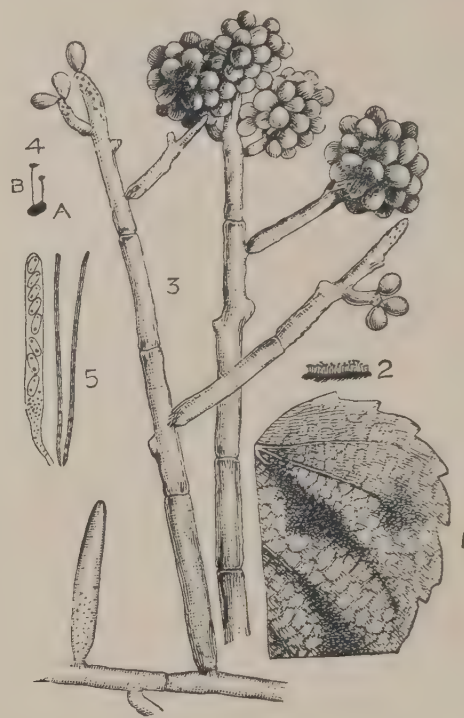


Fig. 163.—Brown Vine Mildew (*Sclerotinia fuckeliana*).

1. Summer fruit on-portion of a Vine leaf (reduced in size). 2. Summer fruit (natural size). 3. Portion of summer fruit (magnified 300). 4. Winter fruit springing from a small black sclerotium (natural size). 5. Mode of spore formation in winter fruit (magnified 200). (*Journal Royal Horticultural Society.*)

Potatoes, Cucumbers, &c., the sclerotia are formed in the pith of the dying stems, where they are often very numerous, and readily seen owing to their black colour when mature. Sclerotia correspond to winter fruit in function; that is, they require a period of rest before they can commence renewed growth. In the case of infested bulbs, the sclerotia rest during winter along with the bulb, and when the latter commences growth in the spring, the sclerotia either at once form mycelium, which passes into, and grows along with the leaves and flowers, coming to the surface of the plant to form spores in the air as the season advances; or the sclerotia at first give origin to a very different form of fruit, resembling in shape a miniature wine-glass, supported on a long, slender stalk, which appears to spring from the ground. This form of fruit produces spores which are liberated at maturity, and those that happen to alight on damp leaves germinate, enter the tissues of the plant, and soon give origin to the summer form of fruit.

When bulbous plants are attacked by disease the bulbs should be examined, and those infested with sclerotia should be destroyed, as

they are certain to produce diseased plants which are of no value, and only spread the disease. Where the disease has existed it is

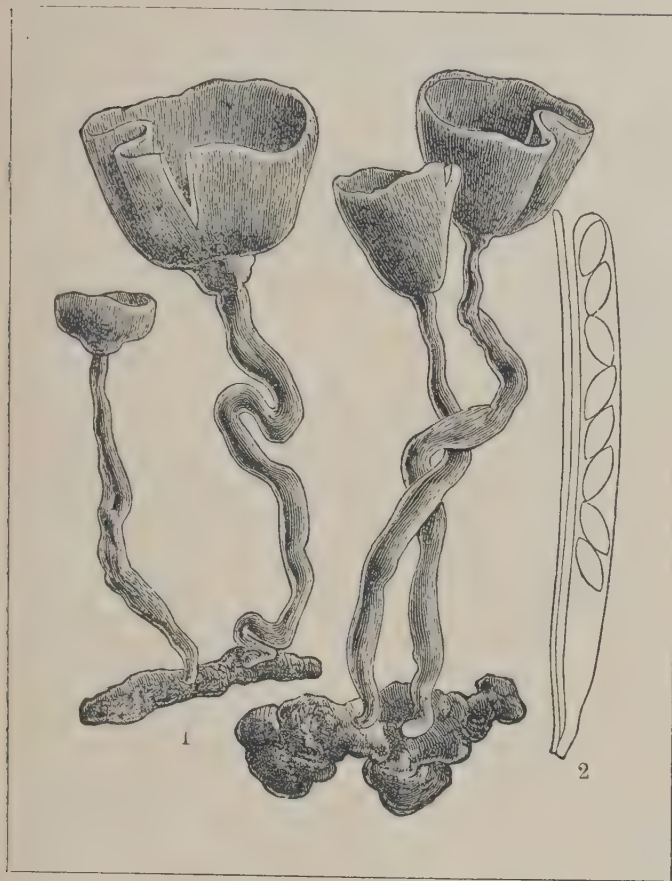


Fig. 164.—Anemone Disease (*Sclerotinia tuberosa*).

1. Winter fruit, the only form known. The cups are bright-brown, and appear just above-ground in early spring. The stem of the cup or fruit springs from a large sclerotium formed in the rhizome of the Anemone (natural size). 2. Spores of winter fruit (magnified 370). (*Gard. Chron.*)

not wise to continue planting bulbs in the same place, as sclerotia are almost certain to be present in the soil, and the new bulbs or leaves would be inoculated. Finally, in the case of Potatoes or Beans, the infected stems should not be allowed to remain on the ground, neither should they be placed on the rubbish-heap, but should be collected and burned. The black sclerotia, about the size of a grain of Wheat, can be readily found in the pith on splitting open the stem, and become liberated when the stem decays. Many kinds of sclerotia are capable of retaining their vitality for years buried in the soil, and when conditions are favourable produce fruit which infects a crop suddenly and unexpectedly. In too many instances the germs of disease, under the form of spores or sclerotia, are unconsciously placed in the soil along with manure, composed in part of decayed plants that have been diseased.

Manure should never be used until it is thoroughly rotten. The use of comparatively fresh or green manure for mulching, &c., is simply courting disease.

Another group of destructive parasitic fungi possess the very remarkable peculiarity of living

on two different host-plants at different periods of their development. About the month of May dirty-orange, soft, gelatinous bodies about $\frac{1}{2}$ inch long may often be found in considerable numbers springing from swollen branches of different kinds of Juniper. These gelatinous masses consist of an accumulation of spores belonging to a fungus called *Gymnosporangium*. These spores germinate on the Juniper branch, and form other very minute spores, which are blown about by wind, and those that happen to alight on the damp leaves of Pear or Hawthorn trees soon germinate, enter the tissue of the leaf, and within a short time give origin to a second form of fruit on the surface of the leaf, resembling clusters of little horns with fringed tips, each about $\frac{1}{6}$ inch long, and springing from a yellow or orange spot on the leaf. This form of the fungus is often very destructive to Pear-trees, and perhaps more especially to various ornamental kinds of Hawthorn, as the fungus usually attacks almost every leaf on the tree, also the young shoots, and even the fruit, causing the leaves to fall early in the season, which results in the wood not being properly matured, and in a lack of reserve food for the following season. If the disease occurs two or three years in succession, the attacked trees usually perish. The spores formed in the horn-like bodies or cluster-cups on the Pear or Hawthorn are in turn scattered by wind, and inoculate



Fig. 165.—Pear-leaf Fungus (*Gymnosporangium clavariæforme*).

1. Spring form of fruit on branch of Juniper (reduced in size). 2. Spore of same (magnified 200). 3 and 4. Summer form of fruit on Pear leaves (reduced in size). 5. Summer form of fruit; A, entire; B, cut open (magnified 10). 6. Spores of summer form of fruit (magnified 200). (*Journal Royal Horticultural Society.*)

the Juniper. The point to remember is, that spores formed on the Juniper can only infect the Pear or Hawthorn, and, on the other hand,

the spores formed on the Pear or Hawthorn can alone infect the Juniper; hence the remedy is in this case easy; remove from the neighbourhood one of the two host-plants, and the fungus cannot continue to produce itself. The two host-plants may be growing quite half a mile apart, the minute spores being conveyed from one to the other by wind, insects, or birds. If it is not desirable to remove either of the host-plants, no pains should be spared to find the diseased Juniper, which can readily be recognized by the swollen diseased part of the branch being covered with the conspicuous yellow fungus. The diseased branch should be removed, as the mycelium of the fungus is perennial in the diseased spot, and produces a crop of spores every spring. Many other very destructive fungi also require two host-plants, among which may be mentioned Wheat-rust or Mildew. The mildew stage proves very destructive to Wheat and other cereals, whereas the second or cluster-cup stage of the same fungus grows on living leaves of the common Barberry.

The very common disease of seedlings, known as *damping off*, is caused by a minute fungus called *Pythium de-baryanum*, a very primitive type of parasite and a typical example of those simple aquatic forms which possess many points in common with the algæ, from which the fungi originated as a specialized branch of organisms in the first instance.

"Damping off" sometimes assumes the form of a serious epidemic in seed-beds, seedlings of various kinds, also the prothalli of ferns, being destroyed wholesale when growing in damp and shaded situations.

The fungi causing this form of disease are so exceedingly minute that they are entirely invisible to the naked eye, and the first indication of their presence is the wilting and falling over of the seedlings attacked. If a seedling that has fallen over is carefully removed from the soil, the collar or portion of the stem just above the ground-line will, on examination, present a shrivelled appearance, and if examined under a microscope, the hyphæ and fruit of the fungus will be seen emerging from the tissues of the seedling.

When once present the disease usually spreads rapidly, destroying all the seedlings within a few days. But this can only occur when the ground is constantly more or less saturated with water. When a seed-bed is infected with the fungus it must not be used for the same purpose again until the soil has been thoroughly

sterilized by the use of quicklime or soot, and exposure to the air.

As illustrations of higher forms of the group of fungi to which *Pythium* belongs—the Phycomycetes—may be mentioned the Vine Mildew (*Peronospora viticola*) and the well-known Potato disease (*Phytophthora infestans*). The summer



Fig. 166.—Vine Mildew (*Peronospora viticola*).

1. Summer form of fungus on grapes (natural size). 2. Summer fruit (magnified 80). 3, 4, 5. Detached spores of summer fruit (magnified 350). 6. Winter form of fruit formed on the mycelium of the fungus present in the tissues of the diseased portion of the plant (magnified 350).

form of fruit of these fungi is an exceedingly delicate white mildew on the surface of living leaves, the conidia as usual being produced rapidly and in immense numbers, thus enabling the disease to spread quickly to adjoining plants. In the case of the Vine, winter fruit is also produced in large numbers in the tissues of diseased and fallen leaves, and unless all such are removed and destroyed there is the danger, or almost certainty, of a recurrence of the disease the following season. Winter fruit is not produced by the fungus causing the Potato disease, but on the other hand the mycelium of the fungus passes from the diseased stems into the tubers, where it extends and passes into the young stems and

leaves the following season; hence Potatoes obtained from a crop that has suffered from disease should on no account be used as "sets".

"Peach leaf curl", a disease often attributed to the presence of insects, and characterized by the blistering and curling of the leaves, most frequently accompanied by an abnormal swelling of the young shoots, is in reality caused by

tinuously until a cure is effected. Other minute fungi closely related to *Exoascus deformans* cause blisters on Plum leaves, the disease known as "bladder-plums" or "pocket-plums", also those dense clusters of branches common on the Cherry, Birch, and other trees, popularly known as "witches' brooms", "bird's nests" &c., in various parts of the country.

In conclusion, the well-known disease called "anbury", "finger-and-toe", or "club-root" attacking the roots of various kinds of wild and cultivated crucifers, as Cabbage, Turnip, Radish, Shepherd's-purse, &c., should be mentioned, although the organism causing it—*Plasmodiophora brassicæ*—is not now classed with the fungi. This disease attacks the roots of plants, causing them to become much distorted and swollen, and finally the plants die. It has been proved that the germs of the disease possess the power of remaining in a living condition in the soil for several years; therefore, when a crop has once been attacked, it is not advisable to use the same ground for the growth of plants susceptible to the disease for some years. Addition of lime to the soil effectually prevents the disease.

FUNGICIDES.

The term fungicide is given to those substances used for the prevention or cure of plant diseases caused by parasitic fungi.

Sulphur.—This is used in the form of a dry powder in the condition called "flowers of sulphur". It is most effective against the group of fungi popularly called mildews, where the mycelium is quite superficial, and forms a white down on the surface of living leaves and fruit, as the Hop Mildew, Vine Mildew, also similar diseases attacking Peas, Marrows, Cucumbers, &c. Better results often follow when finely powdered quicklime is mixed with the sulphur, always having about double the quantity of sulphur. Special bellows are sold for the distribution of the powder.

Bordeaux Mixture.—This is a liquid, and as a fungicide is undoubtedly the best known at present. Owing to the lime present in its composition, plants that have been sprayed with it present the appearance of having received a thin coat of whitewash. This, of course, forbids its use in the conservatory, pleasure-garden, or home park; on the other hand, in the nursery, kitchen-garden, vinery, or other place where appearances can be ignored, Bordeaux mixture is undoubtedly the very best fungicide for

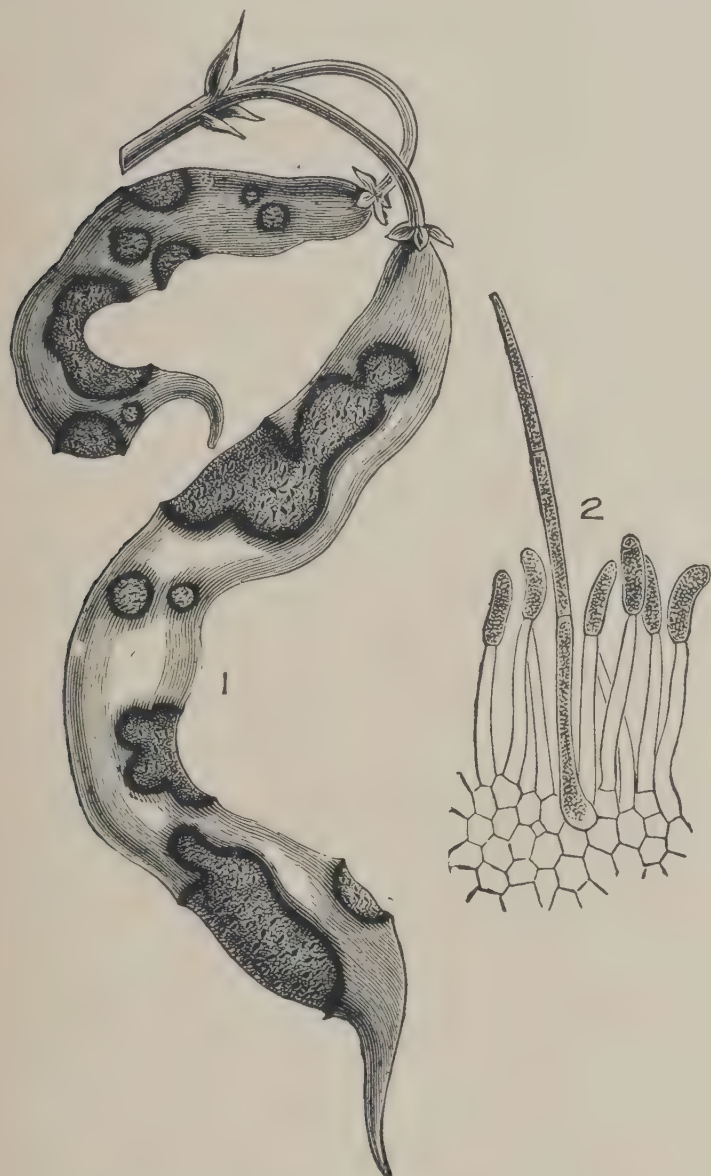


Fig. 167.—French Bean Canker (*Gloeosporium lindemuthianum*).

1. Fruit of French Bean attacked by the fungus, which also attacks Scarlet-runners (natural size). 2. Fruit of fungus (magnified 400). (Gard. Chron.)

a minute fungus called *Exoascus deformans*, which eventually causes the affected parts to present a delicately frosted appearance, due to the formation of its fruit on the surface of the diseased portions. The mycelium of the fungus remains from year to year in the shoots, following the young growth, and producing the disease every season, which eventually kills the tree, as the diseased leaves fall early and there is a lack of reserve material, and the wood is not matured. If diseased branches are cut back beyond the point of infection, and diseased leaves collected and burned, the disease can be arrested; the means of prevention are not difficult, nevertheless the work must be done promptly and con-

general use. It is invaluable for holding in check the numerous minute parasitic fungi forming spots on leaves, which, if allowed to

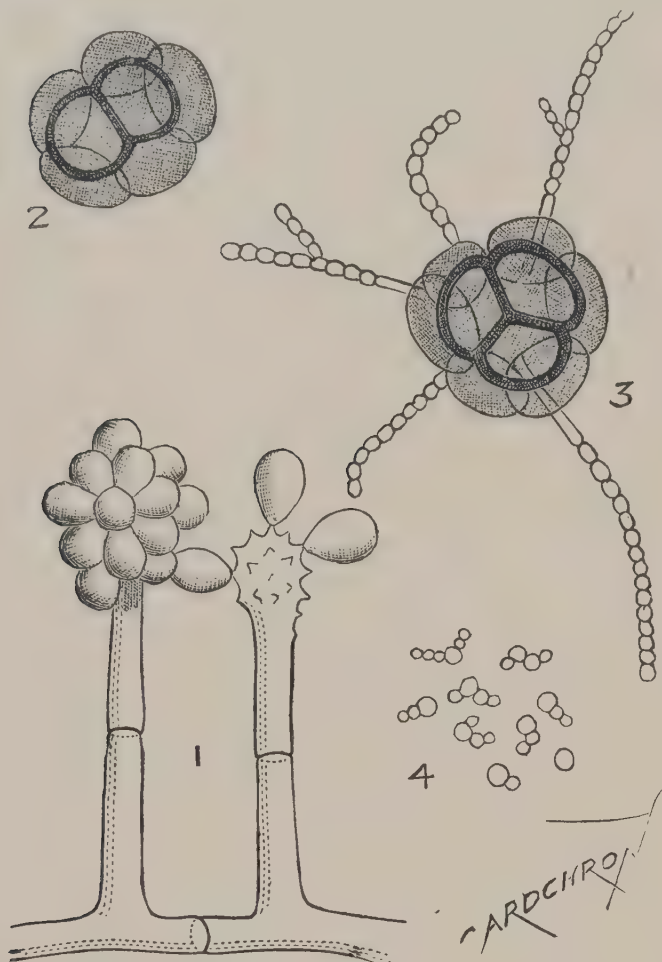


Fig. 168.—Pæony Drooping Disease (*Sclerotinia pæoniæ*).

1. Summer form of fruit (magnified 400). 2. Minute black sclerotia formed in dying leaf-stalks close to the ground. When the leaf-stalk decays these sclerotia rest in the soil until the following spring, when they produce spores as shown in fig. 3, which infect the young leaf-stalks as they push through the soil (magnified 100). 4. Spores produced by sclerotium germinating in the soil (magnified 100).

run their course, cause a premature fall of the foliage, which means badly-matured wood and arrested growth of buds or grafts. In the case of mature fruit-trees, similar fungi first appearing on the leaves, pass on to the fruit and form "scab" of Apples, Pears, &c.; all such are arrested by the fungicide under consideration if spraying is commenced when the leaf-buds are first expanding, and continued at intervals as occasion demands. Potato disease, mildew of Marrows and Cucumbers, Asparagus rust, &c., are also checked by the use of Bordeaux mixture, which is prepared as follows:

Sulphate of copper,	...	...	...	6 lbs.
Unslaked lime,	...	...	...	4 "
Water,	...	...	...	50 gallons.

Dissolve the sulphate of copper separately in a few gallons of water. In another vessel add water gradually to the lime until a thick paste is formed, then when cool, mix the two together, and dilute up to 50 gallons with water.

If the mixture is properly made, the blade of a knife held in the solution for one minute

should be unchanged; if it is coated with copper more lime should be added, and the experiment repeated until no copper adheres to the blade, when it is ready for use.

The mixture should be constantly stirred during spraying, otherwise the sediment settles, and one portion will be too thin to answer the desired end, whereas the other part will be too concentrated, and scorch the foliage. Spraying with Bordeaux mixture should cease when fruit is beginning to ripen, otherwise it is liable to become spotted.

Ammoniacal Solution of Copper Carbonate.

Carbonate of copper,	...	...	5 ounces.
Strong aqua ammonia,	...	...	3 pints.
Water,	...	...	45 gallons.

Dissolve the carbonate of copper in a small quantity of water, then add slowly the liquid ammonia, and finally dilute with 45 gallons of water. The liquid should be perfectly clear, and of a blue colour.

This fungicide is more especially effective against those fungi having the mycelium situated on the surface of the affected host-plant, as Rose Mildew, Hop Mildew, &c., and may be used generally in conservatories, gardens, &c., where, for reasons already stated, Bordeaux mixture cannot be used.

Iron Sulphate Solution.

Iron sulphate,	...	...	20 lbs.
Sulphuric acid,	...	...	1 pint.
Water,	...	...	50 gallons.

Pour the sulphuric acid upon the iron sulphate, then add by degrees 50 gallons of water. A wooden vessel, as a barrel, must be used for



Fig. 169.—Strawberry-leaf Fungus (*Sphaerella fragariæ*).

The spots are whitish at the centre, surrounded by a dark dull-red border. Spraying with Bordeaux mixture checks the disease (natural size). (Gard. Chron.)

the preparation of this mixture, as metal is attacked by the sulphuric acid.

This solution is of great service in destroying the resting-spores of fungi in cases where a

disease has previously existed. In spraying fruit-trees, Vines, &c., the trunk and bark should be thoroughly drenched, so that the solution may reach spores located in crevices of the bark; walls, the ground under fruit-trees, &c., should also be drenched. This work must be done during the winter, before the buds begin to swell, and must not on any account be used when leaves are present, as these are at once completely destroyed by the solution.

Finally, although fungicides made in the proportions given above have been repeatedly proved not to injure mature foliage, nevertheless it is always advisable to commence operations with a more diluted solution, as tender young leaves, or foliage grown under glass, not unfrequently have the cuticle insufficiently developed to resist the action of the fungicide, when spotting or scorching may result.

LITERATURE.

Diseases of Plants induced by Cryptogamic Parasites, Tubeuf & Smith. Longmans & Co. 18s. Contains an account of nearly all known parasites attacking both wild and cultivated plants. Also a general introduction to the subject, preparation and use of fungicides. Numerous illustrations.

A Text-book of Plant Diseases caused by Cryptogamic Parasites. G. Massee. Duckworth & Co. 5s. Describes the diseases of plants cultivated in Britain, India, and the British colonies. General introduction to the study, preparation, and use of fungicides, with preventive and curative methods given under each disease. Numerous illustrations. [G. M.]

CHAPTER XIV.

SOILS.

THE SOIL AND ITS PROPERTIES—TILLAGE OF SOILS—DIFFERENT SOILS, EMPLOYED IN HORTICULTURE—INGREDIENTS OF SOILS—SOURCES OF NITROGEN—DO PLANTS ASSIMILATE FREE NITROGEN?—AZALEA CULTURE.

Formation of the Soil and its Properties.—Soils are formed by the decomposition of rocks, under the influence of air, rain, sun, frost, and the lower plants. If the products of the decomposition of the rocks remain on the place where they have been formed, the composition of the rock in the subsoil will determine the character of the soil resting upon it. In most instances the products of decomposition are partly washed away into streams and creeks, and thence carried into the rivers and into the sea. It is just these, the soluble and more finely pulverized parts, which contain most of the available plant-food. As the current of the rivers becomes slower a great deal of the suspended matter sinks to the bottom: first the

larger stones and pebbles, then sand and fine clay.

The matter held in solution in the waters of the rivers, and so deposited, is taken up by the soils with which they come into contact. In this way the valleys receive a large part of the plant-food which is formed by the decomposition of the rocks at higher levels.

A part, however, of the dissolved and suspended matter is discharged with the river water into the sea. The sea often deposits the material thus obtained in the form of sand and clay, the latter forming a soil of superior fertility. The soils obtained from rocks alone, without any admixture of vegetable matter, are not fertile. In order that they may become so, the products of plant-growth must be mingled with them. When plants grow on a soil they deposit in their dead leaves and stems the organic matter which they have formed by means of their green leaves. The substances formed by the decomposition of this organic matter is called *humus*. To this substance the black colour of garden soils is due. Humus is an organic substance that can be destroyed by fire.

Many of the most important properties of the soil are partly, or almost entirely, due to humus. Plant-growth, however, deposits nitrogen compounds as a part of the humus. These compounds are not contained in rocks, but without them no soil can be fertile. By the decomposition of the organic matter of the plants and of the humus other substances are formed, particularly carbonic acid, that help to decompose the original rocks. Plant roots also, by means of their acidity, actively take part in the decomposition of rocks. At the same time they effectively prevent losses of plant-food by surface drainage.

It is evident to anyone who has observed the nature and disposition of soils, that vast quantities of them have been removed from the localities in which they were originally formed. It is certain that violent eruptions of nature have disturbed the solid masses, scattering at the same time the disintegrated portions that may have been previously reduced to the condition of soils. Light sandy soils in some localities are even now being drifted from place to place by the winds. But the effects of water with regard to the transportation of soils are much more powerful and universal than those resulting from the action of wind. The mechanical effect of water can be traced almost everywhere, in a greater or less degree.

From the quantities of marine shells that are found inland, and at considerable elevations, it would appear that the sea must at some remote period have rolled over the low-lying parts of Great Britain, and swept before it different substances and various kinds of soil. The land may have sunk, for some time, considerably below the level of the sea, or the latter may have been elevated above the surface of the land; in either case the soil and the looser portions of rocks would be moved by the overwhelming force of the mass of water. To this fact must be attributed the formation of those numerous apparently water-formed eminences which diversify the general level of the low parts of the country, and present aspects more or less inclined to the sun, and consequently better adapted for the growth of a greater variety of vegetable productions than a level plain. Were it not for the soil being thrown into a diversified surface we should not, in our latitude, have a country so capable of drainage and improvement, nor one-half so productive, as it can now be made.

The Soil as a source of Plant-food.—In order to start with definite notions about the inherent fertility of soils, let us take as an example an ordinary arable clayey soil in fair condition of productiveness. When all vegetable roots have been removed such land will contain in the first 9 inches of the surface soil a quantity of organic matter containing about 3000 lbs. of nitrogen and 30,000 lbs. of carbon per acre. This nitrogenous organic matter of the soil has been derived either entirely from the decay of vegetable growth left in the land by preceding generations of plants, or possibly to some extent also from past applications of organic manures. When we remember, therefore, that full crops of many of our garden plants only need from 100 to 150 lbs. of nitrogen per acre for their successful growth, it is somewhat surprising to learn that with the large store of organic nitrogen in the soil the gardener finds it necessary to add nitrogenous manures at all, yet the efficiency of even small quantities of nitrate of soda, guano, or ammonium-salts, as fertilizers, has long ago been abundantly proved.

Boussingault showed that the nitrogenous organic matters of ordinary soils are usually inert and inactive for plant-life, their oxidation and nitrification, or in plainer language their decay, being too slow to subserve the requirements of the multitudinous individuals that make up the crops of our gardens and horticultural establishments. Hence the soil left to

its own resources is unable to satisfy the demands made upon it. And even with an abundant dressing of farmyard or stable manure, certain soils may still remain unproductive, owing to the non-nitrification of its organic matter. This may be due to sourness and to a lack of available lime or potash.

We get a fairly correct idea of what takes place in a soil in regard to nitrification from an analysis of the drainage water percolating through it. Professor Dehérain found in 1891 that various soils that had received a copious manuring with about 24 tons of farmyard dung per acre, allowed the following quantities of nitrogen, as nitric acid, to drain away. For comparison is also given the amount of nitrogen as nitric acid percolating through an unmanured soil:—

Nitrogen as Nitrates in Drainage Water.

Seasons.	Quantities of Nitrogen per Acre.	
	Dunged Soil.	Unmanured Soil.
	lbs.	lbs.
Spring, ...	46·1	19·5
Summer, ...	22·6	13·5
Autumn, ...	38·2	28·3
Winter, ...	17·4	13·5
Yearly total,	124·3	74·8

The quantity of nitrogen as nitrates formed in the soil and liable to be washed away is thus seen to be very considerable, ranging from a yearly total of nearly 75 lbs. in the unmanured land to more than 124 lbs. per acre in the dunged soil, the latter being more open and porous and thus more accessible to the oxygen of the air. It is seen that in the dunged soil the greatest loss of nitrogen occurred during the spring months; this was probably owing to the oxidation of the organic matter that had taken place in the winter, and on the approach of spring, there being no growing crop to assimilate it, this very soluble substance was washed into the drainage. There was also a considerable loss in the dunged soil during the autumn, whilst the greatest loss of nitrogen in the unmanured soil occurred in the autumn, the result of the summer nitrification.

Some invaluable experiments of Sir John Lawes and Sir Henry Gilbert, conducted at Rothamsted, Hertfordshire, afford another example of a similar kind. Three drain gauges of unmanured and uncropped soil have been in operation since September, 1870, that is, for twenty-six harvest years to the end of August, 1896.

It is obviously of interest to consider whether or not there is evidence of decline in the amount of nitrogen as nitric acid annually formed in the soil over that period. As the drainage water was not systematically sampled and analysed until the year 1877, accurate estimates of the amount of nitric acid in the drainage water of the first seven years of the experiment cannot be made; but the indication is that it averaged more over the earlier than over the subsequent years. Examination of the results given below for the three five-yearly periods of the eighteen years 1877 to 1895 shows that the average annual loss of nitrogen in the drainage was over 40 lbs. per acre, equal to a loss of about 280 lbs. of nitrate of soda; over the second five years about 32 lbs. of nitrogen, equal to say 200 lbs. of nitrate of soda; the third five years showed a loss of nitrogen of about 30 lbs., which is equivalent to rather less than 200 lbs. of nitrate of soda; whilst in the last three years, 1892 to 1895, the annual loss of nitrogen was more than 32 lbs., equal to 206 lbs. of nitrate of soda. Taking the average loss for four-monthly periods and the total harvest years extending over the same period of eighteen years, it is seen from the following table that from September to December there was a loss of nitrogen equivalent to 126 and 111 lbs. of nitrate of soda respectively; from January to April a loss of 50 lbs. and 63 lbs.; and from May to August 51 lbs. and 44 lbs. The whole harvest year thus shows a total loss by drainage of 227 lbs. and 218 lbs. of nitrate of soda per acre. The loss of nitric acid, that is of soluble plant-food, is found to be very obviously dependent on the amount and on the distribution of the rainfall and of the drainage from the land.

Table showing the Loss of Nitrogen as Nitric Acid, and its equivalent as Nitrate of Soda, per acre from Uncropped and Unmanured Soil at Rothamsted, Hertfordshire.

	Reckoned as Nitrogen.		Reckoned as Nitrate of Soda.	
	Soil 20 ins. deep.	Soil 60 ins. deep.	Soil 20 ins. deep.	Soil 60 ins. deep.
	lbs.	lbs.	lbs.	lbs.
5 years 1877-8 to 1881-2, ...	44.37	42.45	284	271
5 years 1882-3 to 1886-7, ...	32.26	31.67	206	202
5 years 1887-8 to 1891-2, ...	31.55	30.01	202	192
3 years 1892-3 to 1894-5, ...	33.57	30.87	215	197
Sept. 1 to Dec. 31, ...	19.72	17.34	126	111
Jan. 1 to April 30, ...	7.89	9.80	50	63
May 1 to August 31, ...	8.04	6.93	51	44
Total harvest year,	35.65	34.07	227	218

It may be well to note that the whole of the

nitrogen that is shown to be lost by drainage from our soils is not all available to ordinary plants, for the reason that many of these only assimilate the spring or early summer formed nitrates, the principal growth and power of assimilation having ceased by the month of July. Thus we find that the greatest loss occurs from September to December, and the least loss from May to August. Root-crops such as potatoes, beet-root, carrots, onions, turnips, &c., may still get hold of summer-formed nitrates, but the nitrates produced in the autumn and winter are of little use to plants. The spring nitrification alone is, as a rule, quite insufficient for the requirements of the crops then starting into rapid growth, hence the need for and value of increasing quantities of artificially supplied manure.

Dehérain being anxious to ascertain if it was possible to excite in our cultivated soils during the period of spring-time a sufficiently active nitrification of the organic matters, so as to avoid the great expense of nitrogenous artificial manures, instituted a series of experiments with soils obtained from different districts of France in order to determine the point. From the results obtained the following conclusions were drawn:—Trituration or pounding of the soil is a powerful method of causing active nitrification. In making preparation for the winter season, soils should be dug or ploughed, and left in a rough state, with the clods unbroken. There ought to be no trituration if the soil is to remain uncovered during the winter months, the breaking up of the soil particles causing active nitrification, which must be absolutely hurtful; the nitrates formed being dissolved, carried into the drains by rain, or into the lower subsoil, and thus lost. With the return of spring, seed-sowing begins. Trituration should then be as complete as possible, all known methods for pulverizing and crumbling of the soil being adopted. During the growth of the crops the hand-hoe and horse-hoe should be vigorously used, for it was found in these experiments that the weight of beet-roots obtained was in proportion to the number of cross-ploughings the land had received

It may be mentioned, further, that in three soils at Rothamsted, Hertfordshire, in fair agricultural condition, and cultivated as bare fallow since the harvest of the previous year, the amount of nitrogen as nitric acid per acre was found in September and October, to a depth of 27 inches, to be as follows:—No. 1, 56.5 lbs.; No. 2, 58.8 lbs.; and No. 3, 59.9 lbs. Again, the soils

of the various plots in an experimental wheat-field at Rothamsted were sampled in October, 1881, to the depth of 27 inches. There had been much rain after harvest, and the conditions were very favourable to nitrification. The nitrates were found to be located chiefly near the surface, the distribution in the three depths, each of 9 inches, being on the average: 1st 9 inches, 100 lbs. of nitrogen per acre; 2nd 9 inches, 59 lbs. of nitrogen per acre; 3rd 9 inches, 31 lbs. of nitrogen per acre. The quantity of nitrates found in these soils generally bore a distinct relation to the amount of the preceding crop. It appears that the organic nitrogen of permanently unmanured or very poor land nitrifies with more difficulty than does the nitrogen of land that has yielded large crops, or which has received farmyard or other organic manures. It is very important, therefore, for gardeners to bear in mind that the nitrogenous capital of a soil, which represents to a considerable extent its fertility and power of yielding remunerative crops, depends, as a rule, on the bulk and composition of the previous plant residues. *The present condition of a soil is thus in great measure a consequence of its past fertility.*

In ordinary soils the four constituents of sand, lime, clay, and organic matter are generally to be found. In the special soils used in horticulture it is usually the organic matter that predominates and gives to the mould its characteristic properties.

In regard to potash and phosphoric acid, which are present in all good soils, it may be assumed that they are dissolved by the acid secretions from the plants where the roots are in direct contact with these elements.

Humus matter may be taken up in a similar manner, and by some plants more readily than by others. Still, it is not until the nitrogen of the humus has assumed the form of nitric acid that its full effect upon vegetation is realized.

Ferments of the Soil.—We now know that the production of nitrates in the soil—a process of the greatest importance for the nutrition of all horticultural crops—is accomplished by the action of two organisms (bacteria), each of which performs a distinct stage in the work. Warington informs us that by one organism ammonium carbonate is oxidized, and the nitrogen converted into a *nitrite*. By the second organism *nitrites* are converted into *nitrates*. We have here an excellent example of the way in which certain special functions—that is, certain narrowly-limited lines of work—are exercised

by individual species of bacteria. The nitrous organism can oxidize ammonia to nitrite, but it cannot change a nitrite into a nitrate. The nitric organism, on the other hand, oxidizes nitrites readily, but it cannot oxidize ammonia. Both of these organisms are present in all fertile soils, but the formation of nitrites is not usually perceived, as they are at once converted into nitrates.

It may be taken as a general rule that in the absence of the element oxygen, one of the constituents of atmospheric air, bacteria act as a ferment in the soil, splitting or breaking up the organic matter present into the new compounds mentioned above, while in the presence of oxygen the bacteria become the active oxidizing agents. The most important ferment of the soil is decidedly the nitric ferment, that abounds, as we have said, in all fertile soils, and sets free the nitrogen locked up in the otherwise inert organic combinations, and so offers it under a soluble and assimilable form to the plants.

One essential condition for the active processes of oxidation and decomposition is, of course, the presence of air; an open porous soil is thus far more exposed to oxidation and nitrification than one in a closely consolidated condition; hence arises the beneficial effect of mixing porous substances, such as peat, charcoal, and sand, with stiff horticultural moulds. The operations of tillage also tend to promote in the soil oxidation of the organic matter, and assist in its nitrification.

A sufficiency of water is essential for the activity of all living agents; oxidation and decay are thus far more rapid in a moist soil than in a dry one. The constant waterings given to plants in a well-conducted garden provide this condition. It must, however, be remembered that a great excess of water is fatal to oxidation, the admission of air being excluded as soon as the soil is filled with water.

Temperature is another prime factor in determining the rate of oxidation and nitrification in mould; the activity of all living agents, whether animal or vegetable, being dependent on the occurrence of a favourable degree of heat, and being confined to certain specific ranges of temperature. Oxidation is consequently found to be far more rapid in summer than in winter, and much more energetic in hot climates than in cold; accordingly we find it more active in a conservatory than in the open garden.

It is known, further, that the nitrifying organism cannot carry on its work unless it is furnished with some alkaline substance to neutralize the

nitric acid formed; and in leaf-moulds rich in humus the nitrification is sometimes rendered difficult by the lack of such a constituent, which may be either lime, magnesia, or potash. In a great many fertile soils the conveyance of calcareous matters by the frequent waterings suffices to keep a sufficient richness in lime; but in leaf-moulds containing an excess of organic matter the bases rendered soluble by nitrification get rapidly used up, and the moulds in consequence become overcharged with acidity to the injury of the growing plants. It is needful in such cases to apply some potash salt, carbonate of potash being preferred (a constituent of wood ashes), which tends to accelerate the nitrification in an extraordinary manner. In some experiments carried out in Paris by Georges Truffaut in May and June, 1892, carbonate of potash applied as a manure to leaf-mould was found to increase the nitric acid formed by 9·15 per cent in one case and by 5·14 per cent in another; while the addition of lime raised the nitrifying power scarcely a quarter per cent.

In order further to test the nitrifying action, a series of investigations were set on foot with various descriptions of moulds employed in horticulture. In these experiments nitrification and oxidation were found to be more active and regular in leaf-mould than in peat-mould.

The Soil and Water.—Since a certain amount of water is necessary for plant life, it is of great consequence that the soil has the power not only of absorbing moisture from the atmosphere, either in the state of dew, rain, snow, or other aqueous deposits, but of retaining this moisture. This power is, however, possessed by some soils to a much greater extent than by others, and in the most fertile soils it is always found to be greatest.

Schübler, to whom we owe much important information regarding soils, made an elaborate series of experiments on the absorptive and retentive power of soils and their constituents. He found that after seventy-two hours' exposure to moist air humus had taken up nearly two and a half times as much water as clay, and forty times more than sand, which, under the same circumstances, took up sixteen times less than pure clay. In a second series of experiments he placed weighed quantities of the dried soils in funnels, made them perfectly wet by the gradual addition of water, and then left them to drain. As soon as the water ceased to drop from them, the wet masses were carefully weighed. The difference in weight between the dry and wet soils was taken to represent

the amount of water that they would hold after thorough saturation by long-continued rain.

The retentive power of the different soils was then determined by exposing the saturated masses for about four hours to a dry atmosphere, having a temperature of 66° Fahr.

The greater the loss of water experienced under these conditions, the less retentive the soils were shown to be.

The following are some of the results obtained by Schübler:—

	Water Absorbed by 100 parts of Soil.	Of 100 lbs. of Water Absorbed, there Evaporated in four hours, at 66 F°.
	per cent.	lbs.
Sand, ...	25	88
Loamy clay, ...	40	52
Heavy clay, ...	61	35
Pure clay, ...	70	31
Rich garden soil, ...	96	25
Peaty mould, ...	190	21

These differences are mainly dependent on the mechanical texture or porosity of the soil material. In a soil consisting of solid particles of fairly uniform size, the interspaces are about 40 per cent of the volume, whether the particles are large or small; but if the particles are a mixture of large and small (such as gravel and sand), the volume of the interspaces is much diminished. On the other hand, if the particles themselves are porous, as in the case of chalk, loam, and especially of humus, the volume of the interspaces is much increased. It is this volume of the interspaces which determines the amount of water which a soil will contain when perfectly saturated, or the amount of air which it will contain when dry.

The influence of humus on the capacity of a soil for water is remarkable. The surface soil of the experimental wheat-field at Rothamsted was sampled in January, 1869, when saturated with water; the unmanured land contained 32·4 of water per 100 of dry soil; the land manured with farmyard manure for twenty-six years contained 65·8 of water per 100 of soil.

Capillary Power of Soils.—A series of investigations by Zenger show conclusively that the capillary power of soils is greater in proportion as their pores are finer; but fineness of pores must not be confounded with fineness of particles. It is true enough that up to a certain point a soil will have more capillary power in proportion as its particles are more finely divided; but the moment this limit is passed fineness is disadvantageous for capillarity, since the minute particles of earth are apt to cohere

and cling together so closely that few, if any, open spaces are left between them for the admission of water.

The figures in column 1 of the next table represent the percentage amounts of water that were imbibed by the soils which had been screened to a tolerably uniform state of moderate fineness, while in column 2 are given the percentage amounts of water imbibed by the same soils after they had been finely pulverized. It will be noticed that there is but little difference between the second column and the first in the case of soils which are naturally porous. Other experiments have confirmed these results by Zenger. Thus Wilhelm noticed, for example, that a garden loam that naturally imbibed 114 per cent of water could absorb only 62 per cent after it had been pulverized.

				Moderately fine.	Finely pulverized.
Quartz sand,	...	...	...	26	54
Marl,	...	...	...	30	55
Brick-clay,	...	...	...	66	58
Moor earth,	...	...	...	105	101
Calcareous soil,	...	...	...	108	70
Garden loam,	...	...	...	123	...
Soil from a moor meadow,	...	...	...	178	103
Peaty soil,	...	...	..	377	269

The chemical composition of a soil, though far less important than its porosity, may, nevertheless, have some influence upon the rapidity of the capillary movement.

Naturally enough, the power of a soil to hold water tends to retard evaporation from the soil. From some experiments of Sachs it appears that plants cannot exhaust the retentive soils so completely of their water as they can the soils which are non-retentive. Thus, in a loam capable of holding 52 per cent of capillary water, a tobacco plant wilted at night when the soil contained 8 per cent of moisture. In a mixture of humus and sand competent to absorb 46 per cent of moisture, another tobacco plant wilted when the moisture had been reduced to 12 per cent; and in coarse sand which could hold 21 per cent of moisture, a third plant wilted when the proportion had fallen to $1\frac{1}{2}$ per cent. Here the tobacco plant was able to pump the soil almost absolutely dry. In these experiments 44 per cent, 34 per cent, and 19 per cent of water respectively were more or less available for the plant.

Different kinds of plants appear to resemble one another more closely than might have been expected in respect to this power of exhausting soils of their moisture, and the researches of Hellriegel have shown that any soil can supply

plants with all the water they need, and as fast as they need it, so long as the moisture within the soil is not reduced below one-third of the whole amount that it can hold.

Humus or Vegetable Mould.—The importance of humus as a source of nitrogen for crops is most conspicuous when wild plants are considered. It is from the humus of the soil that forest trees and most of the other natural plants, including grasses and clovers, derive the greater part of their nitrogenous food. Some nitrogen, indeed, comes to the land with the rain, dew, and other aqueous deposits that fall upon it. But the amount of this atmospheric nitrogen brought down by rain is comparatively small, and is, by itself, no more than sufficient to nourish a sparse vegetation, or vegetation of a very low order. Some assimilable nitrogen, in the form of nitrates, is found in the waters of brooks also; and the plants which have access to such waters profit by the nitrates that are contained in them, as is shown by the results obtained with irrigation. But only comparatively few plants are so situated that they can be nourished by brook water; and, besides, a good part of the nitrogen in such water is derived, doubtless, from the oxidation of humus higher up the stream.

Humus, in the condition in which it is met with in garden soils, is a mixture of remains of plants in the most diverse stages of decomposition or decay. When roots, leaves, wood, straw, or dung, lie upon or in the earth, they absorb moisture and gradually become brown and soft, then blackish-brown and crumbly, lastly black and pulverulent, as may be very easily traced in the soil covering the ground in forests.

There are two kinds of leaf-mould in use among the French gardeners, called *la terre de bruyère*, and *le terreau de feuilles*. We learn from Georges Truffaut that these two kinds of mould are formed from decomposing plant leaves and roots mixed with ordinary soil or sand and ferric oxide (irony matter), and that these moulds have a peculiar acid property from the humic acid which they contain, which can be made most beneficial for horticultural purposes.

The first description of leaf-mould, *la terre de bruyère* (peat), is formed on sandy heaths by the decay of the leaves and roots of *Erica tetralix*, *E. scoparia*, *E. vagans*, and frequently also from *E. cinerea*, which flourish there, the soil being held together in such a manner by the roots of the growing plants as to allow of its being cut into square blocks, and so despatched

for market. To prepare the material for use, it must be broken up and sifted, removing the larger undecomposed roots which hold the mass together.

The second description of mould, *le terreau de feuilles* (leaf-soil), is different from the former, being obtained from the forests, and is the result of the decomposition of the fallen leaves mixed with the earth upon which they rest; that obtained from under the oak-trees is considered the best. These soils are light in character, and peculiarly suited for the growth of most greenhouse plants. The peculiar property of this leaf-mould is, that it facilitates drainage and aeration, causing a quick and active plant-growth, with a free development of root. The partial decomposing leaves and roots forming the mould require a free passage of air to allow of the nitrification of the organic matter, and, given this, the roots of the growing plants put into it develop rapidly. But as both the drainage and evaporation from such mould are great, frequent waterings become necessary in actual work. The mould has also a large absorptive power: one hundred parts by weight of the mould will take up one hundred and ninety parts by weight of water.

As it is known that the fertility of all classes of soil is closely connected with its powers of retaining plant-food, several experiments have been tried as to the retentive properties of leaf-mould for different manurial substances, which have shown that it has a great absorbent power for potash and phosphoric acid, but that nitrate of soda is retained in a much less degree. These facts agree with what has been found in ordinary agriculture.

The following table shows the amount of selected chemical constituents in 100 parts of the finely sifted leaf-mould obtained from the neighbourhood of Rambouillet (Seine-et-Oise):—

Selected Constituents in parts per hundred of Mould.

	Per cent.
Nitrogen, ...	0.587
Phosphoric acid, ...	0.116
Lime, ...	0.260
Silica (sand), ...	83.600
Humus (organic matter), ...	9.530

It is known that soils containing humus will absorb ammonia from the atmosphere, and thus increase their store of nitrogen. The organic remains of former crops or plants are also oxidized, the nitrogen being converted into nitric acid. The fragments of either silica or limestone will at the same time be more or less disintegrated by the combined action of

water and air, assisted by the carbonic acid and humic acid arising from the decomposition of vegetable matter, and a portion of the insoluble plant-food will thus gradually be brought into a state suited for assimilation by the roots of growing plants.

From several carefully conducted experiments by Georges Truffaut it was found that the leaf-mould on being passed through a sieve yielded 80 parts per 100 of fine soil, and that the weight of fine dry earth in one hectolitre, which is equal to about 3½ cubic feet or 2¾ bushels, was 143 lbs. The sifted-out portion was composed mainly of leaves in an early stage of decomposition, which would act on the soil to which it was added by virtue of its physical properties.

The following table shows the weight of each fertilizing element in one hectolitre of leaf-mould, and its degree of assimilability:—

Assimilable Elements in one Hectolitre of Sifted Leaf-mould.

	Lbs.
Total nitrogen, ...	0.59
Lime, ...	0.34
Phosphoric acid, ...	0.15
Potash, ...	0.46
Silica (sand), ...	108.68
Humus, ...	12.39

Assimilable Elements.

	Grammes
Nitric nitrogen provided in 6 months by nitrification, ...	34.45
Phosphoric acid (soluble), ...	2.60
Potash (soluble), ...	47.45

Knowing, therefore, what are the substances directly assimilable by plants in one hectolitre of leaf-mould, it may be of importance at this stage to inquire the best means of applying to the soil the elements that are wanting, or are not present in sufficient quantity.

Nitrogen.—Although the nitrification in the leaf-mould may be sufficiently active for the gardener to dispense with artificial nitrogenous manures in most cases, yet there are certain species of plants which rapidly develop a large mass of foliage, and these cause a rapid and extensive demand on the nitrogen. For such plants it will always be advisable to use nitrate of soda, nitrate of potash, or guano in solution when watering, and to supply these manures frequently and in small quantities. The presence of crystalline nitrate of soda in direct contact with plant-roots is sometimes hurtful, and the growing plants do not get the full benefit of the supply.

Phosphoric acid.—Assimilable phosphoric acid occurs in very small quantity in leaf-mould; it is therefore necessary to add it in the form of

manure. The best form in which phosphoric acid may be added to leaf-mould is that of pulverized bone-phosphate. Phosphate of potash is also excellent. Superphosphates yield a certain proportion of phosphoric acid soluble in water, but in leaf-mould culture they are not to be recommended, being almost always acid, and this introduction of sulphuric acid into soils poor in lime would be certainly hurtful.

Potash.—Leaf-mould contains a considerable proportion of potash, which is only slowly available for vegetation. For certain cultivations, especially that of Ferns, potash manures have a very beneficial effect when applied to leaf-mould. The most rational method is to use carbonate of potash, and to apply it dissolved in water to the soil to be manured; this salt is retained by the soil, and the plants are able to absorb it as they need. The proportions to be used vary according to the requirements of the plants cultivated.

Different Soils employed in Horticulture.—In an interesting paper by Georges Truffaut, on the chemical and physical properties of different soils employed in horticulture, the author rightly remarks that the exact knowledge to the gardener of the composition of the moulds he cultivates is very important, and that for several reasons, not the least being that this knowledge enables him to use complementary manures for forcing purposes, and to adapt the supply to the requirements of the particular plant he wishes to raise.

In dealing with the question of the formation of soils we have already shown the important part played by decomposing vegetable substances. The humus, or decayed vegetable matter of all soils, has its origin, as we have also seen, in the dead leaves, roots, &c., of previous vegetation. It is continually forming wherever plants grow. It is, in fact, the foundation, and often the entire source, of the organic substances in soil.

Each year a certain portion of the vegetable growth dies off—leaves and branches fall, and parts of the roots decay. Some of the organic substances which fall upon the surface of the ground returns again to the atmosphere; but a certain part remains, and, added to that which decays underground, becomes, as it oxidizes, available for future growth. The atmosphere of the soil, which at first differed but little from that which exists above it, becomes highly charged with carbonic acid, which decomposes the minerals—lime, potash, magnesia—in the soil, and thus, year by year, more and more of

the nitrogen collected by each generation of plants becomes available for the generation that succeeds it.

The following table will illustrate the increase of nitrogen formed during the process of fermentation and decay of certain selected vegetable products:—

Product Examined.	Nitrogen per cent.			Authority.
	In Original Plant.	In the Decomposed Organic Matter.	Increase of Nitrogen.	
Meadow hay, ...	1.62	4.42	2.80	Kostylcheff.
Clover, ...	2.00	5.28	3.28	"
Maize plant, ...	1.88	4.50	2.62	"
Cereal straw, ...	1.27	2.10	0.83	"
Dogwood leaves, ...	1.30	4.70	3.40	Mayer.
Oak leaves, ...	0.80	4.70	3.90	Truffaut.
Heath, ...	0.20	5.10	4.90	"

It will be observed that there is an increase in the amount of nitrogen formed during the decay of the vegetable substances mentioned, ranging from 0.83 per cent in the cereal straw, to nearly 5 per cent in heath.

Deep beds of vegetable mould are frequently met with in forests under trees, and on dry land generally, wherever vegetation is rank and neglected.

It is found that the differences in the chemical composition of the original materials, whether of rocks or of vegetable matter, which compose a soil, mainly account for the enormous variation existing in the different soils under cultivation, and of the amount of organic matter (humus) and of nitrogen which they contain.

The next table shows the amount of nitrogen contained in the leaves of certain trees while in a fresh condition.

Nitrogen in 100 parts of leaves of—

Maple, ...	0.98 per cent.
Plane, ...	0.89 "
Horse-chestnut, ...	0.54 "
Acacia (Robinia), ...	1.05 "
Lime, ...	0.96 "
Service, ...	0.88 "
Ash, ...	0.84 "
Oak, ...	0.80 "
Hazel, ...	0.65 "
Plum, ...	1.08 "
Poplar, ...	0.98 "
Willow, ...	1.28 "
Birch, ...	0.52 "
Elm, ...	0.74 "
Alder, ...	1.36 "
Fir, ...	0.57 "
Catalpa, ...	0.70 "
Average, ...	0.87 per cent.

It is seen that the leaves of the Acacia, Plum, Willow, and Alder are the highest in the ele-

ment nitrogen, and would therefore form the richest mould on their decomposition. The average amount of nitrogen in the seventeen descriptions of leaf is 0·87 per cent. It must, however, be remembered that autumn leaves are necessarily comparatively poor in nitrogen, potash, and phosphoric acid, since these constituents pass out from the leaves into the body of the tree with the approach of winter, there to be held in store for next year's use. In one sense it would be perfectly correct to say that dead autumn leaves, even those that have never been bleached by rain, have been well-nigh exhausted of their most valuable fertilizing constituents. But, as is well known, considerable quantities of the less valuable kinds of ash ingredients, notably silicic acid and lime, together with certain proportions of the more valuable constituents, still remain in fallen leaves.

The next table shows the amount of some selected constituents contained in certain plants, or portions of plants, which may be employed in the production of humus matter of horticultural soils.

Selected Constituents in 100 of Vegetable Substance.

Description of Plant.	Water.	Nitrogen.	Phos- phoric Acid.	Potash.
	per cent.	per cent.	per cent.	per cent.
Heath, ...	20	0·9	0·10	0·40
Fern, ...	16	2·4	0·45	2·40
Furze, ...	16	2·5	0·23	0·80
Horsetail, ...	14	1·8	0·41	2·70
Rushes, ...	18	1·1	0·12	0·43
Moss, ...	25	1·0	0·16	0·29
Leaves of Beech, ...	15	0·8	0·24	2·58
" Oak, ...	15	0·8	0·34	2·02
" Fir, ...	17½	0·5	0·20	0·54
" Pine, ...	13½	0·8	0·10	0·46
" Spruce, ...	12½	0·9	0·20	1·60

These facts teach us that the fertility of soils is due to the richness of the organic residues of previous generations of plants, mixed with certain mineral substances, the most important of which are phosphoric acid and potash.

Little by little, under the combined influence in the soil of moisture and warmth, and the action of bacteria, the compound organic nitrogen of vegetable matter is transformed, and becomes the protean nucleus of microbes, which reproduce themselves with extreme rapidity, having for their object the carrying on of the work of oxidation and conversion from insoluble to soluble plant-food.

The next table illustrates the composition of three different descriptions of mould used for horticultural purposes.

Constituents	Leaf- mould.	Forest- mould.	Peat- mould.
	per cent.	per cent.	per cent.
Organic matter (humus), ...	17·00	8·46	18·80
Clay and silica (sand), ...	79·80	63·34	76·05
Nitrogen, ...	0·50	0·45	1·40
Potash, ...	0·31	0·73	0·31
Phosphoric acid, ...	0·06	0·10	0·20
Lime, ...	0·19	2·08	0·53
Magnesia, ...	—	1·71	—
Soda, ...	—	0·10	—
Iron oxide, ...	0·26	4·98	0·20

The first point to observe is, the large quantity of organic matter present in these soils—in the leaf-mould 17 per cent, in the peat-mould nearly 19 per cent, and in the forest-mould 8½ per cent. In some samples of fertile mould the amount of organic matter will not be more than from 1½ to 2 per cent, while in the famous black soil of Russia it varies from 5 to 12 per cent. It is also seen that these soils contain a large proportion of nitrogen, the leaf and forest moulds containing nearly four times as much as the average of ordinary arable soils, while the peat-mould is considerably more, but much of the nitrogen in the peat would be in a very inert condition.

The next table shows the composition of two leaf-moulds from France, and of one from Ghent, as employed in the horticultural establishments of those countries.

Composition of Leaf-moulds (by Georges Truffaut).

	From Ram- bouillet, France.	From Maurepas, France.	From Ghent, Belgium.
	per cent.	per cent.	per cent.
Organic matter (humus),	9·53	17·00	64·00
Clay and silica (sand),...	83·60	80·55	34·10
Nitrogen, ...	0·59	0·47	1·17
Phosphoric acid, ...	0·12	0·13	0·16
Lime, ...	0·26	0·18	0·35
Potash, ...	0·35	0·50	0·14
Iron oxide, ...	—	0·17	—

The moulds from France correspond much more exactly with those used in England than does that from Belgium, which contains an enormous percentage of humus matter, and is in fact a peat-mould. Now, one of the most delicate points in horticultural chemistry is whether the humus of the soil is or is not directly absorbed by the growing plant. De Saussure concluded that air and water contributed a much larger proportion of the dry substance of plants than did the soils in which they grew. In his view a fertile soil was one which yielded liberally to the plant nitrogenous compounds and mineral ingredients; whilst the carbon, hydrogen, and oxygen of which the greater proportion of the dry substance of the plant was made up, were mainly derived from

air and water. Hence, so far as humus is beneficial to vegetation, it is only by its oxidation and nitrification, and a consequent supply of carbonic acid within the soil—a source of immense importance in the early stages of the life of a plant, and before it has developed and exposed a sufficient amount of green leaf-surface to the atmosphere to render it independent of soil supplies of carbonic acid. It is estimated that the annual production of nitrates within the soil ranges from seventy to eighty pounds of nitrogen per acre in the case of good loamy soils, but the capacity for producing nitrates possessed by a fertile garden soil or leaf-mould containing much organic matter (humus) far exceeds that of ordinary loams.

The following analysis by J. Hughes, F.C.S., represents the composition of a good grape soil from the neighbourhood of Motril, in the south of Spain, and the results will be useful to those interested in the production of grapes:—

	Per cent.
Water lost at 212° Fahr., ...	0·770
* Organic matter and combined water, ...	2·220
Oxide of iron, ...	4·678
Alumina, ...	2·462
Lime, ...	1·019
Magnesia, ...	0·684
Potash, ...	0·266
Soda, ...	0·010
Phosphoric acid, ...	0·070
Carbonic acid, ...	0·440
Sulphuric acid, ...	trace
Chlorine, ...	0·008
† Silica and insoluble silicates, ...	87·373
	100·000
* Containing nitrogen, ...	0·045
† Containing coarse sand, ...	44·360
Stones left on $\frac{5}{16}$ -inch mesh sieve, ...	32·07
Gravel left on $\frac{1}{8}$ -inch mesh sieve, ...	15·74
Total stones, ...	47·81

The soil, as the figures show, consisted largely of stones, there being in round numbers 48 per cent of small stones and gravel having a light-brown ferruginous appearance. The above results certainly indicate a really poor soil when compared with our English soils of average fertility. Thus, in the proportions of nitrogen and phosphoric acid the amounts are quite one-half what we should find in a native soil of average quality; but in regard to potash this soil stands out prominently in richness, and there can be little doubt that one of the greatest qualifications for a successful vine-producing soil must be the presence of plenty of potash in a readily available form. The distinguished French chemist Ville, in his book on manures, lays

particular stress upon the importance of potash for vines. He says: “Where potash is lacking the leaves do not attain their full development; in the month of July they become red and spotted with black, after which they become dry, and are easily reduced to powder under pressure of the fingers”. Further, he adds: “If potash be deficient, little or no fruit makes its appearance”.

The next soil to which we would direct attention is one specially prepared for the cultivation of the Carnation. The available condition of the plant-food depends much on the character of the soil; a much smaller proportion of plant-food will render a sand fertile than would be required in the case of a clay. This is partly from the far greater development of the roots in a sandy soil, and partly from the different condition in which the mineral food is held. Hilgard has also pointed out that the presence of lime in a soil, especially when associated with humus, much increases the availability both of the potash and phosphoric acid, so that smaller quantities of these suffice when lime is present

Percentage Composition of Soils prepared for Carnation Growing.

	Sample 1.	Sample 2.
	per cent.	per cent.
Sand, ...	79·924	79·909
* Organic matter (humus), ...	12·582	11·302
Oxides of iron and alumina, ...	5·220	5·358
Carbonate of lime, ...	1·037	2·382
Magnesia, ...	0·259	0·187
Phosphoric acid, ...	0·369	0·349
Sulphuric acid, ...	0·076	0·065
Potash, ...	0·256	0·206
Soda, ...	0·112	0·096
Chlorine, loss, &c., ...	0·165	0·146
Total, ...	100·000	100·000
* Containing nitrogen, ...	0·386	0·405
Equal ammonia, ...	0·469	0·492

We thus see that sand and organic matter make up about 90 per cent of the total soil thus prepared, with 5 per cent of oxides of iron and alumina, which would consist of a loamy clay, so that this leaves only 5 per cent to be divided among the other ingredients, showing conclusively that the proportion of plant-food present in soils is very small, even when the soil is extremely fertile, the bulk of the soil serving chiefly as a support, and like a sponge to hold water. The percentage of nitrogen in the carnation soils is very large, but it is found, nevertheless, that if the plant is to be grown successfully it must be assisted with some nitrogenous manure of a readily soluble character. This is owing to the fact that a large part of the ele-

ments of plant-food contained in soils, especially if those elements are in an organic form, is present in such a condition that plants are unable to make use of it.

The following table shows the chemical composition of soils recommended as suitable for the cultivation of Vines, Ferns, and Palms, ordinary garden flowers, and stove plants respectively:—

Percentage Composition of various Loams.

Constituents.	For Vines.	For Ferns and Palms.	For Garden Flowers.	For Stove Plants.
* Organic matter (fibrous mould), }	10.39	11.09	13.70	19.38
Sand, ...	78.44	80.28	74.20	66.80
Iron oxide, ...	0.20	0.50	0.62	0.26
Alumina (clay), ...	9.98	7.50	10.00	13.00
Lime, ...	0.66	0.29	0.67	0.19
Potash, ...	0.20	0.20	0.33	0.31
Phosphoric acid, ...	0.13	0.14	0.48	0.06
Total, ...	100.00	100.00	100.00	100.00
* Containing nitrogen,	0.468	0.367	0.229	0.238

Doubtless the best soil for ordinary horticultural purposes, and especially for vine-growing, is a good yellow turfy loam, which has been piled up until well seasoned, with the organic matter partially decomposed.

Sands.—Sufficient attention is not always paid to the selection of the sand used for horticultural purposes. Truffaut says: “We should take care that the sands we use are not contaminated with soil, or even by the least trace of clay; for without that precaution sands lose all their main properties”.

In England the fine quartz sand and the marine alluvial sand from the district of Reading (Surrey) are frequently used. In France the alluvial sands of the Loire and the Allier are held in high esteem on account of their multiplicity of ligneous plants. In Bedfordshire is found a quartz-like sand of large grains and transparent, which imparts to the compost into which it enters some very remarkable physical properties. The same description of sand is found on the coast of St. Martin à Étamps, and in the neighbourhood of Dormans, France.

Both in England and on the Continent road-scrapings are frequently employed as a component part of horticultural composts. Such material is useful as giving a mixture of sand, a certain quantity of fine mould, with chemical ingredients of both a mineral and nitrogenous character.

The following table shows the percentage

chemical composition of road-scrapings from Trappes (Seine-et-Oise), France:—

Composition of Road-scrapings in parts per 100.

Sand, ...	93.87
Organic matter, ...	3.65
Mould, ...	0.90
Nitrogen, ...	0.15
Phosphoric acid, ...	0.06
Lime, ...	0.14
Iron oxide, ...	0.73
Potash, ...	0.48

The data thus given shows that road-scrapings must act beneficially rather by their mechanical influence on the compost with which they may be mixed than by any manurial ingredient they contain.

Nitrogen in Soils.—It is just about a century since the question of the sources of the nitrogen of vegetation became a subject of experimental inquiry, and also of conflicting opinion. It is about half a century since Boussingault was led by a study of the chemistry of agricultural production to see the importance of determining the sources of the nitrogen periodically available to vegetation over a given area of land. Somewhat later the Rothamsted experiments, now in their fifty-second year, were commenced by Sir John Lawes and Sir Henry Gilbert, and in the progress of these investigations many facts have been elicited bearing upon this important subject. Still, almost from the date of Boussingault’s first researches the question has been one of controversy, and even at the present time very conflicting views are entertained respecting it.

Messrs. Lawes and Gilbert have frequently pointed out how entirely inadequate is the amount of combined nitrogen coming down in the measurable aqueous deposits from the atmosphere to supply the nitrogen of the vegetation of a given area. Other possible supplies of combined nitrogen from the atmosphere have also been considered, and pronounced inadequate. Again, the question whether or not plants assimilate the free or uncombined nitrogen of the atmosphere has been the subject of laborious experimental inquiry, and also of critical discussion, at Rothamsted. Finally, the question whether the stores of the soil itself are an important source of the nitrogen of our crops, both of the farm and of the garden, has also been considered.

It may at the outset be frankly admitted that so long as the facts of production alone are studied, without knowledge of, or reference to, the changes in the stock of the nitrogen in the

soil, it would seem essential to assume that a large proportion of the nitrogen of crops growing without any direct supply of it by manure must be derived, in some way or other, from atmospheric sources.

The assumption which is most in favour with some prominent writers is, that whilst some plants derive most or all of their nitrogen from the stores of the soil itself, or from manure applied to it, others derive a large proportion from the free nitrogen of the atmosphere. Lawes and Gilbert, on the other hand, whilst freely admitting that the facts of production are not conclusively explained thereby, have maintained that such collateral evidence as the determinations of nitrogen in our soils afford, are in favour of the supposition that the soil may be the source of the otherwise unexplained supply of nitrogen. This latter conclusion has been frequently stated in general terms, but until recently there has not been published the numerical results upon which it is based.

If, then, the supply of mineral constituents in the soil not being defective, the yield of our crops is in the main dependent on the amount of nitrogen which is available to them within the period of their growth from the soil itself, or from the manure applied to it, surely the fertility of a soil must be largely measured by the amount it contains, and the degree in which it becomes available. And if this be so, it proves that the soil is a "*laboratory*" in which chemical food is being prepared for the use of plants, as well as a "*mine*" in which this prepared food is stored up.

In reference to this point it may be stated, by the analyses of some prairie soils from Illinois and the North-west Territory of America, that they were found to be about twice as rich in nitrogen as the average of arable soils in Great Britain. Indeed, they corresponded in their amount of nitrogen very closely with the surface-soils of our permanent pasture-land. As the virgin prairie soils have their source of nitrogen in the accumulation from ages of natural vegetation, with little or no removal, it has also been found they are correspondingly rich in potash and other mineral constituents, showing that the soils of the "New World" as well as those of the "Old World" are "mines" as well as "laboratories". If not, what, it may be asked, is the meaning of the term a *fertile soil*?

The Sources of the Nitrogen of Crops.—We will next consider whence comes the nitrogen of crops, and especially whence comes the much larger amount taken up by plants of the legu-

minous, and some other families, than by the Gramineæ, to which latter family belong the grasses of our meadows and lawns; Wheat, Barley, Oats, and Rye; Maize and Sugar-cane.

Combined Nitrogen in Rain, &c.—It has been assumed by some writers that the amount of combined nitrogen annually coming down in the measured aqueous deposits from the atmosphere is sufficient for all the requirements of annual growth. In Liebig's earlier writings he assumed the probability of a much larger quantity of ammonia coming down in rain than he did subsequently; but even in his more recent work, the *Natural Laws of Husbandry*, published in 1863, he supposes that as much as 24 lbs. of nitrogen per acre may be annually available to vegetation from that source. Such an amount would, it is obvious, do much towards meeting the requirements of many of the crops grown in the garden.

The earliest considerable series of determinations of the amount of ammonia coming down in rain in the open country were by Boussingault, in Alsace. He gives the amount of ammonia per million of rain-water in each fall for a period of between five and six months, May to October, 1852; but he does not calculate the amount so coming down over a given area of land.

His average amount of ammonia per million of rain-water was, however, somewhat less than that found in the Rothamsted rain-waters collected in 1855 and 1856; which, calculated according to the rainfall of the periods, gives the following amounts of nitrogen so coming down per acre. The amount of nitrogen as nitric acid, and the amount of total combined nitrogen as ammonia and nitric acid together, are also given.

Nitrogen, as Ammonia and Nitric Acid, in the Rainfall of three years, at Rothamsted, Hertfordshire, in pounds per acre.

Years.	Rainfall.	Nitrogen, per acre, as—		
		Ammonia.	Nitric Acid.	Total Nitrogen.
	inches.	lbs.	lbs.	lbs.
1853-54, ...	29·014	5·20	0·74	5·94
1855, ...	29·166	5·82	0·72	6·58
1856, ...	27·215	7·28	0·76	8·00
Mean, ...	28·465	6·10	0·74	6·84

It will be seen that according to these results an average of 6·54 pounds was contributed per acre per annum in the rain in the form of ammonia and nitric acid. More recently, however, Dr. Faulkland has determined the amount of ammonia and nitric acid in numerous samples

of rain and snow-water, dew and hoar-frost, collected at Rothamsted from April 1869 to May 1870 inclusive, and the average amount of ammonia per million of water found by him is considerably lower than the earlier determinations show. The results are given below.

Table showing the Maximum, Minimum, and Mean Amount of certain Constituents found in Samples of Dew and Hoar-frost, in parts per million.

	Total Solid Matter.	Carbon in Organic Matter.	Nitrogen as—				Chlorine.	Hardness.
			Organic Matter.	Ammonia.	Nitric Acid.	Total Nitrogen.		
Highest proportion, ...	80.0	4.50	1.96	2.31	0.50	4.55	8.0	25
Lowest proportion, ...	26.4	1.95	0.26	1.07	0.28	1.66	3.5	13
Mean of all, ...	48.7	2.64	0.76	1.63	0.40	2.79	5.3	19

These small deposits of dew and hoar-frost condensed from the lower stratum of the atmosphere contain, on an average, three or four times the amount of organic carbon, organic nitrogen, ammonia, and nitric acid, found in the analyses of rain-water. The total quantity of solid matter, and the amount of chlorides, is also larger, but the difference is much smaller than in the case of the other ingredients.

Dr. R. Angus Smith, the great chemist, in

his work entitled *Air and Rain, the Beginnings of a Chemical Climatology*, 1872, gives the results of numerous analyses of rain-water collected both in country and town districts in the United Kingdom. The amounts of ammonia and nitric acid in the rain vary exceedingly, according to locality; but the amounts in the rain of country places accord generally with those found in the Rothamsted rainfall previously given.

Average Composition of Samples of Rain from various districts of England and Scotland, in parts per million of Water.

				Nitrogen as—		Chlorine.	Sulphuric Acid.
				Ammonia.	Nitric Acid.		
England, country places, inland, ...				0.88	0.19	3.88	5.52
„ towns, ...				4.25	0.22	8.46	34.27
Scotland, country places, sea coast, ...				0.61	0.11	12.24	5.64
„ „ „ inland, ...				0.44	0.08	3.28	2.06
„ towns, ...				3.15	0.30	5.70	16.50
„ Glasgow, ...				7.49	0.63	8.72	70.19

The ammonia of the atmosphere is found to be derived from the decay of animal and vegetable matters, both on land and in the ocean, also from the combustion of fuel, especially coal, hence the richness of rain-water, more particularly in sulphuric acid, which falls in the vicinity of towns.

Chlorides are principally furnished by the sea, fine spray of salt-water being carried long distances by high winds. At Cirencester the chlorides in the rain are on the average equal to about 53 lbs. of common salt per acre per annum; at Rothamsted, Hertfordshire, the quantity is about 22 lbs. per acre.

From the foregoing data it will be seen how entirely inadequate is the amount of combined nitrogen available from atmospheric sources to supply the requirements of different garden crops without some nitrogenous manure.

It is true that the minor aqueous deposits from the atmosphere, dew, frost, &c., are much richer in plant-food than rain, and there can be

no doubt that there would be more deposited within the pores of a given area of soil than on an equal area of the non-porous even surface of a rain-gauge. How much, however, of this might be available beyond that determined in the collected aqueous deposits, existing evidence does not afford the means of estimating with certainty.

Other Sources of Combined Nitrogen.—It has been argued that, in the last stages of the decomposition of organic matter in the soil, hydrogen is evolved, and that this nascent hydrogen combines with the free nitrogen of the atmosphere, and so forms ammonia. Again, it has been suggested that ozone may be evolved in the oxidation of organic matter in the soil, and that, uniting with free nitrogen, nitric acid would be produced. If the supplies of nitrogen from the atmosphere to the soil itself are inadequate for plant-growth, it may be asked, how about the direct supplies of free nitrogen from the atmosphere to the plant?

One view which has been advocated is, that broad-leaved plants have the power of taking up combined nitrogen from the atmosphere in a manner, or in a degree, not possessed by the narrow-leaved gramineous plants. The only experiments that we are aware of, made to determine whether plants can take up nitrogen by their leaves from ammonia supplied to them in the ambient atmosphere, are those of Adolph Mayer in Germany, and of Schlösing in France. Both found that very small quantities of nitrogen were taken up, but both concluded that the action takes place in a very immaterial degree in natural vegetation. It has been found, however, that if a small quantity of guano is placed in water over a hot-water pipe of a greenhouse and allowed to evaporate, that the ammonia gas given off will be absorbed by the foliage of the plants growing therein, and they will assume a dark-green tint. Carbonate of ammonia treated in the same way will have a similar effect.

It is well known that, under the conditions in which crops are grown in ordinary agriculture, nitrogenous manures have very direct effects in increasing the produce of Wheat, of Barley and of Oats, of Turnips, of Mangel and of Potatoes. This is the case notwithstanding that in the cereals the increased produce consists characteristically of the non-nitrogenous substances starch and cellulose, in the root-crops of the non-nitrogenous substance sugar, and in potatoes of the non-nitrogenous substance starch. Leguminous crops, on the other hand, not only as a rule accumulate much more nitrogen over a given area of land under equal soil conditions, and contain a higher percentage of nitrogen in their dry substance, than the crops above enumerated, but there is abundant evidence that they also derive much nitrogen from the combined nitrogen of the soil and sub-soil, and further, that they probably take up much as nitric acid; yet it is generally recognized in practical agriculture, that direct nitrogenous manures have comparatively little effect in increasing the produce of such crops.

As each of the above-mentioned crops has its counterpart in the garden, it will be of interest to show the influence of nitrogenous manures in increasing the production of the non-nitrogenous constituents in those plants.

As will be seen, the following table shows the estimated amounts of carbon, per acre per annum, in the total produce (grain and straw) of Wheat and of Barley, in the roots of Sugar-beet and of Mangel-wurzel, in the tubers of

Potatoes, and in the total produce (corn and straw) of Beans, when each is grown by a complex mineral manure without nitrogen, and also when grown with the same mineral manure with nitrogenous manures in addition.

Next is shown the estimated gain of carbon, that is, the increased amount of it accumulated in the crop under the influence of the nitrogenous manures. The estimated increased production of total carbohydrates, under the influence of nitrogenous manures, is then given; and lastly, the estimated gain of carbohydrates for one pound of nitrogen supplied in manure. Such estimates can obviously be only approximations to the truth; but, accepted as such, they are of interest and of use, as conveying some definite impression of the influence of nitrogenous manures on carbon-assimilation, and on carbohydrate (starchy) formation in plants.

It will be seen that, independently of the underground growth, the Wheat was estimated to assimilate 988 lbs. of carbon per acre per annum under the influence of a complex mineral manure alone; and that the amount was increased to 1590 lbs. by the addition of 43 lbs. of nitrogen as ammonium salts, to 2222 lbs. by 86 lbs. of nitrogen as ammonium salts, and to 2500 lbs. by 86 lbs. of nitrogen as sodium nitrate. Accordingly, as shown in the second column, the increased assimilation of carbon was, by 43 lbs. of nitrogen as ammonium salts, 602 lbs.; by 86 lbs. as ammonium salts, 1234 lbs.; and by 86 lbs. as sodium nitrate, 1512 lbs.

Reckoned in the same way, the increased assimilation of carbon in the Barley was, for 43 lbs. of nitrogen as ammonium salts, 950 lbs. per acre; that is, one-and-a-half times as much as by the same application in the case of Wheat.

In the Sugar-beet the increased assimilation of carbon, and accumulation of it in the roots, was 1477 lbs. per acre by the application of 86 lbs. of nitrogen as ammonium salts, and 1908 lbs. by 86 lbs. of nitrogen as sodium nitrate. There was, therefore, more increased assimilation of carbon, and accumulation of it in the roots of the Sugar-beet, than in the grain and straw of Wheat by the same applications of nitrogenous manure.

In the Mangel-wurzel the increased accumulation of carbon in the roots was 1130 lbs. by 86 lbs. of nitrogen as ammonium salts, and 1370 lbs. by 86 lbs. as nitrate; that is, less than in the removed crops of Wheat, and considerably less than in the removed crops of Sugar-beet.

Estimates of the Yield and Gain of Carbon, and of the Increased Produce of Carbohydrates, per acre per annum, in various Crops, grown at Rothamsted, Hertfordshire.

	Carbon.		Carbohydrates.	
	Actual.	Gain.	Gain.	For 1 lb. Nitrogen in Manure.
<i>Wheat, twenty years, 1852-71.</i>				
	lbs.	lbs.	lbs.	lbs.
Mineral manure, ...	988	—	—	—
Do. and 43 lbs. nitrogen as ammonia, ...	1590	602	1240	28·8
Do. and 86 lbs. nitrogen as ammonia, ...	2222	1234	2550	29·7
Do. and 86 lbs. nitrogen as nitrate, ...	2500	1512	3140	36·5
<i>Barley, twenty years, 1852-71.</i>				
Mineral manure, ...	1138	—	—	—
Do. and 43 lbs. nitrogen as ammonia, ...	2088	950	1992	46·3
<i>Sugar-beet, three years, 1871-73.</i>				
Mineral manure, ...	1123	—	—	—
Do. and 86 lbs. nitrogen as ammonia, ...	2600	1477	3188	37·1
Do. and 86 lbs. nitrogen as nitrate, ...	3031	1908	4052	47·1
<i>Mangel-wurzel, eight years, 1876-83.</i>				
Mineral manure, ...	759	—	—	—
Do. and 86 lbs. nitrogen as ammonia, ...	1889	1130	2376	27·6
Do. and 86 lbs. nitrogen as nitrate, ...	2129	1370	2771	32·2
<i>Potatoes, ten years, 1876-85.</i>				
Mineral manure, ...	1021	—	—	—
Do. and 86 lbs. nitrogen as ammonia, ...	1783	762	1507	17·5
Do. and 86 lbs. nitrogen as nitrate, ...	1752	731	1416	16·5
<i>Beans, eight years, 1862 and 1864-70.</i>				
Mineral manure, ...	726	—	—	—
Do. and 86 lbs. nitrogen as nitrate, ...	992	266	474	5·5

In Potatoes, reckoned on the increased production of tubers only, the increased yield of carbon by 86 lbs. of nitrogen as ammonium salts was 762 lbs. per acre, and by 86 lbs. as sodium nitrate, 731 lbs. That is to say, there was considerably less increased production of starch in Potatoes than of sugar in Sugar-beet or Mangel-wurzel by the same applications of nitrogenous manure.

Lastly, in the Leguminous crop—Beans, with its high yield of nitrogen per acre, and the high percentage of nitrogen in its dry substance—the increased assimilation of carbon under the influence of nitrogenous manure was, comparatively, quite insignificant. Thus, there was, by the application of 86 lbs. of nitrogen as sodium nitrate, an increased assimilation of carbon of only 266 lbs. per acre, or little more than one-sixth as much as in Wheat, and little more than one-eighth as much as in Sugar-beet, by the same application.

Turning to the figures in the third column of the foregoing table, it is seen that there was

a very greatly increased production of the non-nitrogenous bodies—the carbohydrates—by the use of nitrogenous manures. Thus, by the use of 43 lbs. of nitrogen as ammonium salts, there was an estimated increase of 1240 lbs. of carbohydrates in the grain and straw of Wheat, and of 1992 lbs. in those of Barley. By the application of 86 lbs. of nitrogen as ammonium salts there was an increased formation of 2550 lbs. of carbohydrates in Wheat, of 3188 lbs. in Sugar-beet, of 2376 lbs. in Mangel-wurzel, and of only 1507 lbs. in Potatoes; and when 86 lbs. were applied as sodium nitrate there was an increased production of 3140 lbs. in Wheat, of 4052 lbs. in Sugar-beet, of 2771 lbs. in Mangel-wurzel, and of only 1416 lbs. in Potatoes; whilst, compared with these amounts, there was in Beans, by the same application, an increase of only 474 lbs. of carbohydrates.

The last column shows the increased amounts of carbohydrates produced for 1 lb. of nitrogen supplied in manure in the different cases. Thus, when 43 lbs. of nitrogen were applied as am-

monium salts, 1 lb. of nitrogen in manure gave an increased production of 28·8 lbs. of carbohydrates in the grain and straw of Wheat, and of 46·3 lbs. in those of Barley; when 86 lbs. were applied as ammonium salts, 1 lb. gave an increase of 29·7 lbs. carbohydrates in Wheat, 37·1 lbs. in Sugar-beet, 27·6 lbs. in Mangel-wurzel, and 17·5 lbs. in Potatoes. Again, when 86 lbs. were applied as sodium nitrate, 1 lb. gave an increase of 36·5 lbs. carbohydrates in Wheat, 47·1 lbs. in Sugar-beet, 32·2 lbs. in Mangel-wurzel, 16·5 lbs. in Potatoes, and only 5·5 lbs. in the Leguminous crop—Beans.

Thus, then, we have the apparently anomalous result, that the crops which are characterized by yielding a comparatively small amount of nitrogen over a given area, by containing a comparatively low percentage of nitrogen in their dry substance, and by yielding comparatively large amounts of the non-nitrogenous products—starch, sugar, and cellulose—are especially benefited by the application of nitrogenous manures, and under their influence yield greatly increased amounts of those non-nitrogenous bodies; whilst the Leguminous crops, which contain a much higher percentage of nitrogen, and yield much more nitrogen over a given area of land under the same soil and season conditions, are much less benefited by such manures.

Without attempting to give an adequate physiological explanation of this curious result, some of the facts bearing upon it are briefly stated by Lawes and Gilbert as follows:—The non-Leguminous crops having comparatively limited power of accumulating nitrogen under given soil conditions, they generally require nitrogenous manuring; the amount of nitrogen assimilated to a great extent rules the amount of chlorophyll formed; chlorophyll formation is an essential condition of carbon assimilation; the amount of carbon assimilated is the chief measure of the quantity of produce; and since the more special or characteristic products of the non-Leguminous crops are the non-nitrogenous substances, the carbohydrates, the natural result of the increased assimilation of nitrogen, and the consequent increased luxuriance in plants is an increased formation of the bodies which are their essential products.

The fact is, that whilst it can hardly be said that there remains an unsolved problem in the matter of the sources of the nitrogen of Wheat, of Barley, and of Grasses, as representatives of the great family of the *Gramineæ*; of Turnips, representing the *Cruciferae*; of some varieties of

Beet, representing the *Chenopodiaceæ*; and of Potatoes of the *Solaneæ*—it must be admitted to be quite otherwise so far as our Leguminous crops are concerned.

Do Plants Assimilate Free Nitrogen?—It is nearly a century ago since the question whether plants took up, or evolved, free nitrogen, became a matter of experiment and discussion; and it is just about half a century since Boussingault commenced experiments to determine whether plants assimilate free nitrogen. From his results he concluded that they did not; and those obtained at Rothamsted by Lawes and Gilbert, about thirty years ago, confirmed the conclusions of Boussingault. In fact, it was concluded that under the conditions of those experiments, which were those of sterilization and inclosure, in which therefore the action both of electricity and of microbes was excluded, the results were conclusive against the supposition that, under such conditions, the higher chlorophyllous plants can directly fix free nitrogen, either by their leaves or otherwise.

It may, indeed, be concluded that, at any rate in the case of Gramineous, Cruciferous, Chenopodiaceous, and Solaneous crops, free nitrogen is not the source. Nevertheless it has long been admitted that existing evidence was insufficient to explain the source of the whole of the nitrogen of the *Leguminosæ*; that there was, in fact, a missing link.

According to some even recent experimenters, however, gain of nitrogen is not limited to our Leguminous crops; and the modes of explanation of the gains which have been observed are extremely various. Thus, it has been assumed that *combined* nitrogen was absorbed from the air either by the soil or by the plant; that there is fixation of free nitrogen within the soil by the agency of porous and alkaline bodies; that there is fixation by the plant itself; that there is fixation within the soil by the agency of electricity; and, finally, that there is fixation under the influence of micro-organisms within the soil, both with and without the accompanying growth of higher plants. During the last few years the discussion has assumed a somewhat different aspect.

The question still is, however, whether free nitrogen is an important source of the nitrogen of vegetation generally, but especially of the *Leguminosæ*; but whilst few now assume that the higher chlorophyllous plants directly assimilate free nitrogen, it is nevertheless supposed to be brought under contribution in various ways, but especially by being brought into combina-

tion under the influence of micro-organisms, or of other lower forms, either within the soil itself, or in symbiotic growth with a higher plant.

Of all the recent results bearing upon the subject, those of Hellriegel and Wilfarth with certain Leguminous plants seem to be by far the most definite and significant; pointing to the conclusion that, although the higher chlorophyllous plants may not directly utilize free nitrogen, some of them, at any rate, may acquire nitrogen brought into combination under the influence of lower organisms; the development of which is, apparently, in some cases a coincident of the growth of the higher plant whose nutrition they are to serve.

As to the explanation of the fixation of free nitrogen, the facts at command do not favour the conclusion that under the influence of symbiosis the higher plant itself was enabled to fix the free nitrogen of the air by its leaves. Nor does the evidence point to the conclusion that the nodule-bacteria became distributed through the soil and there fixed free nitrogen, the compounds of nitrogen so produced being taken up by the higher plant. It seems more consistent, both with experimental results and with general ideas, to suppose that the nodule-bacteria fixes free nitrogen within the plant, and that the higher plant absorbs the nitrogenous compounds produced. In other words, there is no evidence that the chlorophyllous plant itself fixes free nitrogen, or that the fixation takes place within the soil, but it is more probable that the lower organisms fix the free nitrogen. If this should eventually be established, we have to recognize a new power of living organisms—that of assimilating an elementary substance. But this would only be an extension of the fact that lower organisms are capable of performing assimilation work which the higher plant cannot accomplish; whilst it would be a further instance of lower organisms serving the higher.

Finally, it may be observed that Loew has suggested that the vegetable cell, with its active protoplasm, if in an alkaline condition, might fix free nitrogen with the formation of ammonium nitrate.

As to the importance of the fixation of the nitrogen of the air for horticulture, and for vegetation generally, there is much yet to learn. It is obvious that different *Papilionaceæ* growing under the same external conditions manifest very different susceptibility to, or power to take advantage of, the symbiosis.

The fact, as shown by Prof. Nobbe, that Papilionaceous shrubs and trees—the follow-

ing being those experimented with: *Robinia Pseudacacia* (locust tree), *Cytisus Laburnum* (laburnum), and *Gleditschia triacantha* (honey locust), as well as herbaceous plants—are susceptible to the symbiosis, and under its influence may gain much nitrogen, is of interest from a scientific point of view as serving to explain the source of some of the combined nitrogen accumulated through ages on the surface of the globe; and also from a practical point of view, since, especially in tropical countries, such plants yield many important food materials, as well as other industrial products.

Exhaustion of Plant-food in Soils.—It needs to be said, perhaps, that the word “exhaustion”, as used in horticulture, has no very precise meaning. It is a term based on money values, rather than on scientific conceptions. It is true enough that, in many situations, land may be utterly ruined by improper or careless cultivation, for the richest soils in the world, if badly used, will produce but comparatively few profitable crops, after which they become less and less productive, until in the end the gardens are left barren or to weeds. Strictly speaking, a soil is exhausted, as regards any particular crop, whenever the cost of cultivation comes to as much as the crop is worth.

The word “condition” is in very common use amongst cultivators of the soil. It is said that a piece of land or a garden is “in condition” or “out of condition”, or in “high condition” or in “low condition”. These terms are well understood to imply certain states of fertility. The word “condition” thus refers to those elements of fertility in a soil which, whether they have been accumulated by natural processes or by the art of the gardener, are capable of being turned to account in the growth of plants and crops within a limited period of time, and which by such growth are soon exhausted. “Condition” is, therefore, something altogether distinct from the natural or inherent fertility of the soil. A soil may be naturally very fertile, but at the same time very much out of condition; or it may be naturally very poor, but in very high condition.

The proportion of plant-food present in soils is very small, even in gardens where the soil is extremely fertile, the bulk of the soil serving chiefly as a support and as a sponge to hold water for the use of plants. But in addition to all this, it must be remembered that the roots of plants, or rather matters exuded by the roots, play a very important part in dissolving substances out of the soil which mere water would

be incapable of dissolving. The little root-hairs, in particular, which cling so tightly to the soil, are active agents both for absorbing food from the soil water, and for dissolving plant-food from the earth.

If we bear in mind the enormous weight of soil which covers every acre of land, and then the small quantity of nitrogen, phosphoric acid, or potash required for any one crop, we find that there is a stock or store of plant-food in every cultivated soil which it would take very many crops to exhaust. Yet, on the other hand, a large part of the elements of plant-food contained in soils is present in such a form that plants are unable to make use of it. An acre of land may contain many thousand pounds of phosphoric acid, potash, or nitrogen, and yet be in a poor condition; while a manurial dressing, supplying fifty pounds of readily available phosphate, or nitrogen, in the form of superphosphate, guano, nitrate soda, or ammonia salts, may greatly increase its productiveness.

The available character of the plant-food depends very much on the description of the soil. A much smaller proportion of plant-food will render a sand fertile than would be required in the case of a stiff clay. This results partly from the far greater development of the plant roots in a sandy soil, and partly from the different condition in which the mineral food is held by the soil.

Hilgard has pointed out that the presence of lime in a soil, especially when associated with humus, much increases the availability both of potash and phosphoric acid, so that smaller quantities of these ingredients suffice when lime is also present.

Food can be taken up by the roots of plants only when it is in solution, or in a condition capable of being dissolved by contact with the acid sap of the root-hairs.

Matter which is in neither of these conditions is for the time useless to the plant, though it may afterwards become available by the chemical action within the soil. Most of the ingredients of soil are in a compound form, and are held very tenaciously by the soil. This fact is really of the utmost advantage, for if it were otherwise many soils would lose their fertility by heavy rains or by constant artificial waterings.

The nitrogen contained in humus matter, such as leaf-mould, peat-mould, and the like, is not in a condition to serve as plant-food; to become available, it must be converted into ammonia and nitric acid. This is accomplished by certain bacteria in the soil, to which reference has al-

ready been made, the carbon of the humus being at the same time oxidized to carbonic acid, whereby heat is developed. This change of insoluble into soluble plant-food is always going on in the surface soils of rich garden-moulds, and as the nitrates are formed they are at once taken up by the growing plant; or if there is no plant at hand, then the soluble constituents are washed away by the rains, and thus a constant exhaustion of plant-food in soils that are uncropped is being brought about. In rich garden soils the production of available plant-food is at its maximum, and so is also the waste by drainage if proper care be not taken.

Some Reasons for Tillage of Soils.—The operations of tillage and drainage of soils serve in many important ways to make the conditions of plant life more favourable, and to increase the amount of plant-food which is at the disposal of a crop. By tillage, aided by frost, and by alternate drought and rain, the surface soil is pulverized, and brought into a loose, open condition. The fine tilth thus obtained allows of a rapid extension of the delicate root-fibres, and also greatly increases the surface of soil particles upon which the root-hairs feed.

In spring-time our fields and gardens are often in a state quite unadapted for sowing seed or setting out plants. The soil is so compact at the surface that the gardener cannot bury or cover seed easily and uniformly, and if he should fairly start the crops, they would, as a rule, not thrive as he desired. The soil, however well it was loosened up last year, has settled down so that the particles are in the closest contact with each other. It is rain falling upon newly-loosened tilth which especially aids in compacting it. Not only does the falling weight of the rain-drops actually beat down the surface of the earth, but the filling of the pores of the soil by copious rains partly or fully floats the smaller grains and fine silt and clay, and then, when the water runs off below, the whole mass sinks by a nearer fitting together of the light, mobile parts among each other and among the heavier, less disturbed portions. The smaller grains of sand and silt fill up the spaces between the larger, and the microscopic rock-dust and the invisible clay atoms run like mortar into the finest cavities. Each heavy rain produces to some extent a closer readjustment of the particles of soils, and increases its compactness.

The degree of compactness that ensues depends somewhat upon the kind of particles which compose the soil. A sand consisting of spherical grains, all of uniform size, does not settle by

standing or by being rained or tramped upon, nor is it loosened by ploughing, digging, or any kind of tillage, for its particles, like the grains in a vessel of shot, readily and inevitably take on their closest contact when released from any disturbance. A sandy loam containing particles of all shapes and of very many sizes would, on the other hand, evidently admit of still closer fitting and packing, and would undergo the most alteration of bulk between tillage and rest. In case of clay consisting mainly of very fine particles, the compactness would be greater in virtue of special properties that do not belong to sand. Grains of sand stick together with slight energy if moist, for the water which adheres to them acts as a weak cement. When the water dries out the grains fall apart.

Particles of clay, when moist, also adhere together, but much more closely and firmly than those of sand; so firmly, indeed, that the clay is plastic, and may be moulded to shape by the hand or on the potter's wheel. Clay mixed with sand renders the mixture plastic; in fact, heavy clays, almost too tenacious for tillage, consist very largely of sand and silt, and rarely contain more than 25 per cent of real clay. When moist clay dries, the particles stick to each other with greater tenacity than before, and as the water evaporates the clay shrinks to a hard mass that requires pounding in a mortar to reduce it to powder. Here is an actual cohesion of particle to particle which water diminishes.

A full consideration of these facts makes it quite evident that in most soils there are tendencies constantly exerted, with more or less vigour, towards mechanical compacting, and one of the important offices of tillage is to counteract these tendencies.

After this discussion of the points involved in the natural compacting of soils, and in overcoming this tendency by tillage so as to prepare a suitable seed-bed and rooting-place for a young crop, let us turn to some notice of how tillage may affect the crop itself, which in course of time comes to develop upon the land.

That crops require water, and that they demand a large amount of it, are statements made evident to us by our common experience. That too much water damages plants and crops is also a fact which requires no illustration. How much water plants require is a question that is not easy to answer, and the share which is taken in the production of garden crops by water-supply—by the excess or by the deficiency, and by the distribution of water—is not easy to estimate.

It is a fairly-well settled fact that water, to be of any use to plants, must become a part of the soil, and although without a suitable climate and good weather, giving alternations of rainfall and sunshine, gardening, as well as agriculture, would shortly be brought to a stand-still, it is also a fact that the actual coming together of plants and water into mutual relations takes place mostly in the soil, and the really critical passages in these relations are largely determined by the soil and by those qualities of it which are amenable to the influence of tillage.

Fertility of Soils.—It is frequently a matter of surprise, especially to farmers, who are apt to lament the exhaustion of their soils, that gardens that have been cropped for years are so much more fertile as a rule than are their fields. There are many causes for this, such as better drainage, more thorough tillage, a more varied rotation of crops, to say nothing of shelter.

In regard to cultivation it may be stated that agricultural tilths range from 3 inches to 9 inches, with an average of about 5 inches; whilst horticultural tilths range from 6 inches to 36 inches or more, and average probably about 18 inches in depth.

But the main reason why the soil of old gardens is so fertile is, that there is a vast accumulation of animal and vegetable matter containing organic nitrogen, that is to say, nitrogen in combination with carbon.

The manner in which soil supports the life of plants and animals is still mysterious, in the sense that we are yet in the dark as to the nature of many of the substances contained in the soil, of the changes which they undergo, and of the part which they take in plant nutrition. This is specially true with regard to the organic matters, consisting of carbon, nitrogen, hydrogen, and oxygen, which the soil contains. The nitrogenous organic matter of a soil, as we have before mentioned, has been derived principally from the decay of vegetable matter left in the land by succeeding generations of plants. And the nitrogenous capital or fertility of a soil depends, as a rule, on the bulk and composition of the previous crop residues, and on the extent to which these have been subsequently destroyed.

Evidently, therefore, the crop which leaves behind the largest amount of roots, stubble, and foliage will best maintain or increase the nitrogenous and organic capital of the soil, while the crop leaving the smallest residue in the soil will be most exhausting in its effect.

Permanent pastures, prairie lands, garden soils, and forests will thus stand at the head of the list

of conservers of soil nitrogen, while arable land from which most of the soil is carted away will be placed at the opposite end of the scale.

The following table illustrates the amount of nitrogen and of organic matter, both per acre and in parts per hundred, in various soils and moulds,

reckoning the top 9 inches of dry soil in each case to weigh approximately the following:—

Arable soil, ...	...	3,000,000 lbs. per acre
Pasture soil,...	...	2,250,000 lbs. „
Leaf-mould, ...	...	1,500,000 lbs. „
Peat-mould, ...	...	1,000,000 lbs. „

Table showing the amounts of Nitrogen and of Organic Matter in various Soils, in quantities per cent and per acre.

	Per Cent.		Per Acre.	
	Nitrogen.	Organic Matter.	Nitrogen.	Organic Matter.
	per cent.	per cent.	lbs.	lbs.
Arable land, Rothamsted, ...	0·106	1·12	3,195	33,450
Old pasture land, „	0·247	3·38	5,558	76,050
Old kitchen-garden, „	0·510	—	11,475	—
Prairie land, Niverville, Manitoba, ...	0·261	3·42	5,873	76,950
„ Brandon, „	0·187	2·66	4,208	59,850
„ Selkirk, „	0·618	7·58	13,905	170,550
„ Winnipeg, „	0·428	5·21	9,630	117,225
Black soil, Russia, ...	0·607	7·00	13,658	157,500
Forest-mould, „	0·450	8·46	6,750	126,900
Leaf-mould No. 1, France, ...	5·00	17·00	7,500	85,000
Leaf-mould No. 2, „	5·87	9·53	8,805	141,950
Peat-mould, „	5·00	18·80	5,000	188,000
Heath-mould, Ghent	11·65	64·00	11,650	640,000

An inspection of these figures will show how enormously the different soils vary in richness of nitrogen and organic matter, and hence in fertility and power of providing nutriment to plants.

In a peat-bog we find the conditions most favourable for the accumulation of organic matter. The Sphagnum and other bog plants cover the surface with a perennial growth, which supplies annually a large residue of dead vegetable matter; while the soil being water-logged, and necessarily free from carbonate of calcium, the oxidation of this vegetable residue is reduced to a minimum.

In fertile meadows and prairie lands we have conditions much more favourable to oxidation. The soil here is not water-logged, but fairly well aerated, and oxidizing agents, both animal and vegetable, are abundantly present. The land being, however, always covered by a thick vegetable growth, considerable accumulations of organic matter may take place in the soil, though never to the extent observed in a peat-bog.

Turning now to arable land, we find that the conditions have become so favourable to oxidation that loss rather than gain of soil nitrogen is probably the general rule. Oxidation is here greatly assisted by the operations of tillage, and by the fact that the land lies in a state of

fallow during a considerable part of most years. In such soils large quantities of nitric acid are produced, which may be washed out by winter rains and lost. As all arable land was once pasture or forest, the loss of nitrogen and of organic matter that has occurred during cultivation is obvious.

The rapid oxidation of organic matter which occurs under tillage means the production of a large amount of available plant-food. The nitrates produced, though liable to be lost by drainage, are also equally capable of yielding valuable crops, and the skill of the gardener is displayed in so arranging his methods of culture that the nitrates shall be a source of profit instead of loss.

Soils suitable for Azalea Culture.—It may be of interest and value, before passing on to discuss the subject of manures, to give some account of investigations by Georges Truffaut on the growth and culture of *Azalea indica*. In dealing with the history of the Azalea he says that the culture of the Azalea has widely extended during the last thirty years, the centre of production in France being Versailles, whence the nurserymen annually send more than 100,000 plants into the market, and even this does not satisfy the increasing demand. In fact, as the horticultural trade cannot find in France a sufficient quantity of these plants, they are

forced to buy extensive quantities every year from the Belgians, who appear to have at their disposal a leaf-mould, improperly called "Ghent heath-mould", which is the ideal soil for the culture of Azaleas. The French, like the English horticulturists, have to obtain, with great trouble and considerable expense, leaf-moulds of inferior quality. The author has, therefore, devoted much attention, and has made valuable scientific researches, in order to overcome the difficulties of the situation.

His method was first to find out what chemical plant-food the Azalea abstracts from the soil during growth. Then, by submitting to analyses various leaf-moulds in which cultivation has shown the best results, to ascertain what are those elements which, by their abundance, produce the greatest fertility; and, as a consequence, what are the constituents lacking in an inferior

leaf-mould that must be added in the form of manure to ensure success.

At Versailles, during the first and second periods of growth of the Azalea, the horticulturists employ peat-moulds obtained from the neighbourhood of Maurepas (Seine-et-Oise), which are similar to those coming from the district of Rambouillet.

The Ghent mould in its density and compactness is very nearly identical with that found in the vicinity of Maurepas, although there is in its composition a greater quantity of vegetable matter, in a not very advanced stage of decomposition. Therefore the quantity of fine mould, after passing through a sieve, is less than in the case of the other moulds.

The following table shows the comparative value, according to the chemical composition, of four descriptions of leaf-mould:—

Composition of Leaf-moulds: Constituents given in parts per 1000.

	Leaf-mould from Rambouillet.	Leaf-mould from Maurepas.	Peat-mould from Maurepas.	Leaf-mould from Ghent.
Quantity of Fine Mould in 1000 lbs. bulk, ..	800	615	730	590
Nitrogen, ...	5.9	4.7	5.0	11.7
Phosphoric acid, ...	1.2	1.3	0.6	1.6
Lime, ...	2.6	1.8	1.9	3.5
Potash, ...	3.5	5.0	3.1	1.4
Silica, ...	836.0	805.5	790.5	341.0
Iron oxide, ...	—	1.7	2.6	—
Organic matter, ...	95.3	170.0	188.0	640.0

The data thus given shows that the Ghent mould is exceedingly rich in nitrogen, which is to be accounted for by the greater abundance of organic matter, and its large proportion of lime, which favours nitrification. The three other moulds contain only about one-half as much nitrogen as the Ghent mould, and they do not vary very greatly among themselves in this constituent.

It is known that the production of nitrates in a soil is of the greatest importance to vegetation, nitrates being the form in which nitrogenous food is chiefly assimilated by plants; the abundance or poverty of nitrates in a mould thus determines to a large extent the luxuriance of plant-growth which the soil is capable of producing. Hence can be easily understood the cause of the exceeding richness of the Ghent mould, each one thousand pounds containing 640 pounds of organic matter, $3\frac{1}{2}$ pounds of lime, and 341 pounds of silica (sand), to assist in aeration and drainage. Phosphoric acid is also very abundant in Ghent mould, the quantity of

this constituent in the Maurepas peat, on the contrary, being extremely small.

On the other hand, while the leaf-moulds from Versailles are slightly weaker in phosphoric acid than the Ghent mould, they are considerably ahead in potash, containing on the average just about three times as much.

It seems fairly evident, therefore, that the superiority of Ghent mould for the culture of the Azalea consists in its richness in organic nitrogen. It is probable also that, independently of its liberal supply of organic matter, of lime, potash, and phosphoric acid, the beneficial effects of the mould are in a considerable degree due to its influence on the mechanical condition of the soil with which it may be incorporated, rendering this more porous and easily permeable to the surface roots, upon the proper development of which the success of Azalea culture so much depends.

Culture of Azalea indica at Versailles.—The variety selected for experiment was that known as Madame Van der Cruyssen, and the investigations extended over three years.

The amount of dry substance accumulated by the plants from the soil during their early growth as cuttings may be stated as follows:—

Dry substance in leaves, 52 per cent.			
„	„	stems, 45	„
„	„	roots, 77	„

One-year-old plants of Azalea contain in their different organs for each one hundred of dry substance accumulated, the following amounts of nitrogen and mineral matter (ash):—

Parts of the Plant.			Nitrogen.	Mixed Matter (Ash).
			per cent.	per cent.
Flowers,	...	...	2.62	(?)
Leaves,	...	...	1.86	3.80
Stems,	...	...	1.12	4.20
Roots,	...	...	0.96	5.30

The following analysis shows the composition of the mineral matter (ashes) of the different organs of the Azalea plant:—

Selected Constituents.	Leaves.	Stems.	Roots.
	per cent.	per cent.	per cent.
Potash,	8.88	14.20	8.29
Phosphoric acid,	6.88	5.76	3.20
Lime,	18.90	21.72	2.13
Iron oxide,	0.12	0.12	0.10
Silica,	46.00	27.20	78.00

These results teach us that the quantity of nitrogen contained in the leaf-mould used for these experiments was much beyond the requirements of the Azalea. But as this nitrogen exists in the mould in combination with other organic matters it does not become soluble, and in a condition to be absorbed by the plant, except by very slow degrees. Consequently the actual amount of nitrogenous plant-food provided can only be reckoned by the nitric nitrogen which is transformed and made assimilable by the process of nitrification, and which takes place in the soil during growth.

From the average of many experiments it was found that in the course of one year a superficial yard of the mould used would yield by nitrification the following amounts of nitric nitrogen:—

	Weight in ½ yard.	Nitrogen in ½ yard.
Peat-mould,	61.5 lbs.	10.88 grammes.
Leaf-mould,	68.5 „	37.01 „
Total in 1 yard,	130.0 „	47.89 „

Thus, during the first year of growth of the Azalea plants there would be placed at their disposal in each yard of mould, equal 130 lbs., 47.89 grammes of soluble nitrogenous food, while the analysis of the different organs of the plants showed that they had absorbed only

14.77 grammes. It is tolerably certain that in leaf-moulds, where organic matter (humus) and lime exist in any quantity, the nitrification that goes on is most intense, and must provide abundance of the richest plant-food.

Turning now to a consideration of the mineral ingredients placed at the disposal of the plants by Ghent leaf-mould, and the leaf-moulds from Versailles, during the period of one year, we find the following results:—

Selected Constituents.	Ghent Leaf-mould.	Maurepas equal parts Leaf and Peat Moulds.
	grammes.	grammes.
Lime,	107.07	56.54
Phosphoric acid,	17.13	11.03
Potash,	24.78	36.44

These figures show that the Ghent mould produces in an equal period of time 35 per cent more assimilable phosphoric acid, and about 48 per cent more of lime. Therefore, by adding a phosphatic manure to the French leaf-moulds to supply the deficiency of phosphoric acid, it is possible to obtain a mould of equal value with the Ghent mould.

If a gardener has to do with a soil which is naturally rich, like the Ghent leaf-mould, a soil which may contain in its upper layers, say 1000 lbs. of phosphoric acid per acre, from which the plants may draw without stint the amount they require, then the demands on the solubility of the phosphate are small. But if, on the other hand, the soil is deficient in phosphoric acid, or contains this constituent in comparatively small quantities, as the Maurepas moulds, then the demands on the solubility of the phosphate are naturally much greater. The mould rich in phosphoric acid would need only to supply the plants with a phosphate manure of which say 5 per cent was soluble; but the mould poor in phosphoric acid must be provided with a phosphate manure of which not less than 10 per cent is soluble in order to obtain equal results. Hence, to raise the moulds of Versailles to a point of equal productiveness with the Ghent mould, even in the first year of growth of the Azalea, an application of bone-meal, phosphate powder (basic slag), or mineral superphosphate must be applied.

Second Year of Growth.—In the month of April of the second year, the greater number of the young plants were covered with flowers; these blooms were found to contain about 6 per cent of dry substance and 2.8 per cent of nitrogen. It was surprising to find that the Azalea flowers contained 44.3 per cent of sugar in their

composition, and that 30·5 per cent of this was cane-sugar, whereas previously it had always been considered of a glucose nature.

The second year's plants were found to contain in their different organs the following constituents:—

Parts of Plant.	Dry Substance.	In the Dry Substance.	
		Nitrogen.	Mineral Matter (Ash).
	grammes.	grammes.	grammes.
In the leaves, ...	1293	24·04	33·43
In the stem, ...	1007	11·27	42·30
In the roots, ...	993	9·53	52·63
Total plant, ...	3293	44·84	128·36

It is of interest to notice that during the second year of growth of the Azalea, as was observed in that of the first year, the maximum of nitrogen was found in the leaves. While, however, in the first year the quantity of nitrogen contained in the roots was greater than that in the stems, the contrary was found to be the case during the second year of growth.

The mineral substances abstracted by the Azalea from the soil during its second year were as follows:—

(Quantities in grammes.)

Constituents.	In Leaves.	In Stems.	In Roots.	In Total Plant.
Lime, ...	6·31	9·18	1·12	16·61
Potash, ...	2·96	6·00	4·36	13·32
Phosphoric acid, ...	2·29	2·43	1·68	6·40
Iron oxide, ...	0·57	0·72	0·94	2·23
Silica, ...	15·37	11·50	41·05	67·92

These results prove that the Versailles leaf-mould provides even in the second year a sufficient amount of nitrogen for the requirements of the Azalea plant, although the Ghent mould places at the disposal of the plant a greater excess of this element. In regard to mineral substances, the two soils furnish in the second year the following proportions:—

Constituents.	Ghent Mould.	Maurepas Mould.
	grammes.	grammes.
Lime, ...	110·11	55·68
Phosphoric acid, ...	17·61	12·58
Potash, ...	25·00	31·46

Each of these soils provides the plants with a sufficiency of mineral food, but the Ghent mould gives much the larger quantity of lime and phosphoric acid; and it is important to note that the plants utilize more food during the second year's growth than during the first. It

is concluded, therefore, that as during the second year's growth of the Azaleas the assimilation of plant-food is more rapid, it is necessary, for the purpose of bringing up the French moulds to the standard of the Belgian, that an application be made of superphosphate with a small quantity of nitrate of soda.

It was found that at the end of the second period the plants had made twice as much dry substance of roots as at the end of the first period in an equal area of soil, consequently the assimilation of food was facilitated, and explains the cause of the greater vegetative powers of the Azaleas during the second year of their culture.

Third Year of Growth.—In the month of May of the third year the Azaleas are planted in a bed of leaf-mould, about forty plants to the square yard, this being the last change of soil to which they are submitted before their consignment for sale in the following September.

The amount of plant-growth produced during the third year is shown by the following results:—

(Quantities in grammes.)

Parts of Plant.	Dry Substance.	Nitrogen in Dry.	Mineral Matter (Ash).
In the leaves, ...	1052	19·57	39·63
In the stems, ...	576	6·45	24·19
In the roots, ...	801	7·68	42·43
In total plant, ...	2429	33·70	106·25

The mineral matter on being submitted to analysis gave the following results:—

(Quantities in grammes.)

Constituents.	In Leaves.	In Stems.	In Roots.	In Total Plant.
Lime, ...	7·30	5·25	0·90	13·45
Potash, ...	3·51	3·33	3·51	10·35
Phosphoric acid, ...	2·72	1·39	1·35	5·46
Iron oxide, ...	0·61	0·41	0·72	1·74
Silica, ...	18·39	0·70	33·19	52·28

These figures show that during the last twenty-seven months of their culture the Azaleas find in the leaf-mould in which they are grown a sufficient quantity both of nitrogen and of mineral substances to supply their wants, the Ghent mould, as before, giving the greater excess. The soluble plant-food is much less drawn upon for nutrition in the third than in the second year of growth.

The general conclusions of the investigation may be briefly summarized as follows:—

1. The leaf-moulds, both of Maurepas and of Ghent, are sufficiently rich in mineral constituents, and the nitrification of the organic nitrogen is active enough to supply all that is wanted by the Azaleas.

2. Ghent leaf-mould always furnishes the plants with a greater quantity of assimilable nitrogen, of phosphoric acid, and of lime.

3. It is during the second year of culture that Azaleas derive from the soil the maximum of plant-food.

4. Azaleas abstract from the soil the following elements, arranged in order of prominence—silica, nitrogen, lime, potash, phosphoric acid, and iron oxide.

5. In order to imitate as nearly as possible the Belgian horticulturists, who obtain such excellent results with Azaleas, it is necessary to add to the leaf-moulds obtained from the environs of Paris a certain quantity of phosphatic manure.

After the experiments made at Versailles in 1892, a manurial application was given to a two-years-old Azalea plant, planted in Maurepas leaf-mould, at the rate of 155 grains of phosphate of lime and 300 grains of nitrate of soda on each square yard of soil, which produced a very sensible effect, causing the plant to grow with exceptional vigour. The leaves became larger, and of a deeper-green colour. Two prunings of the plant were able to be performed instead of one.

For several years it has been observed that a mixture of mould and of dried-blood manure, applied as a top-dressing, produced an analogous effect upon Azalea plants, the colour being more pronounced and the vigour greater.

Finally, it may be asked, What is the significance of these facts? In the first place, it is that the character of development of the Azalea depends very much upon the proportion of nitrogen available within the soil, because, where there is restricted growth of plant, there will not be vegetative activity, or, in other words, a great accumulation of texture-forming substances, upon which the plant must eventually rely for flower formation and maturation. But in order that the nitrogen may work successfully it becomes absolutely necessary that there shall also be plenty of available minerals in the soil to combine with the nitrogen, nitrogen being the element which is mostly conducive to vegetable growth, and therefore if present in excess likely to interfere with, if not altogether prevent, maturity of growth. For there can be no doubt that strength of plant depends on favourable development of

the woody substance, and the more this prevails, the more will the accumulated nitrogen be diluted—in other words, show a lower proportion to the other constituents. [J. J. W.]

CHAPTER XV.

MANURES.

ORGANIC MANURES—INORGANIC MANURES—THE EFFECT OF MANURES.

Though the general term manures is well understood by almost every gardener, recent progress in horticultural science has had a tendency to give a distinctness and definiteness to the term which was previously impossible on account of the lack of accurate knowledge, but which, while yearly becoming better understood, is not yet so clear in the minds of all gardeners as to make a further study of the subject of no value.

All substances which, when added to the soil, increase its fertility may be considered as manures. These may act either directly, by supplying food to plants, or indirectly, by rendering the substances already contained in the soil available for the nourishment of plants. The necessity of the application of manures is self-evident; for, as plants withdraw certain elements from the soil, the latter would in course of time become exhausted if no restoration of them were made.

Manures may be divided into two classes:—

1. Organic manures, or those of vegetable and animal origin.

2. Inorganic manures, or those of mineral origin.

The immediate effect of a manure depends (1) on its solubility, and (2) on the suitability of the plant-food which it contains for the use of the plant it is applied to.

Manures may be further classified into “general” and “special”. General manures are those which contain all the essential constituents of plant-food, while special manures are those which are valuable chiefly for one such constituent, though sometimes more are present.

Though the general manures contain all the necessary constituents of plant-growth, yet they do not necessarily contain them either in the amount or the proportions required by a particular plant, so that their use may not be economical. For example, if the soil contains an ample supply of nitrogen and potash, but is

deficient in phosphoric acid, and a general manure is used, only the phosphoric acid in it will be of any use, while the nitrogen and potash it contains will yield no return, and the nitrogen at least will always be liable to waste by drainage. For the economical use of manures considerable knowledge and discretion are required, in order to judge of the condition of the soil and the requirements of the crop; for it must be remembered that it is the constituent of plant-food required which is present in the soil in least proportion compared with the requirements of the plant which controls the extent of the crop. If there is enough of this least-plentiful constituent for producing a full crop, all will be well; but if there is not sufficient, a full crop cannot be obtained, even though other ingredients of plant-food are present in very large quantity.

I. ORGANIC MANURES.

In this class are included all substances of vegetable and animal origin which have the property of enriching the soil, or of supplying it with substances required by plants for food. All vegetable and animal substances used as manure must undergo decomposition before they can become the food of plants, for the roots of these only absorb liquids and gases. This change is generally effected to a certain extent in the compost heap or dung clamp, before they are applied to the soil; but in the case of green manures, it takes place entirely in the soil.

Leaves.—These, when thoroughly decayed and reduced to the state of mould, form a sort of manure which, alone or mixed with soil or other substances, is eminently suited for the growth of most plants. Leaf-mould, as it is called, is generally in great request for the cultivation of pot plants. Autumn leaves are necessarily comparatively poor in manurial constituents, since these elements pass out from the leaves into the body of the tree with the approach of winter, there to be held in store for next year's use. The best quality of autumn leaves recently fallen from hardwood trees, would contain in one ton, say, 6 lbs. of potash, about 3 lbs. of phosphoric acid, and from 10 to 15 lbs. of nitrogen.

Peat.—Bog or moor peat may be said to be an accumulation of humus, produced by the decay of plants that have been more or less submerged; and it would then seem to be derived from that which forms the first food

of vegetation. But in the formation of peat highly antiseptic properties have been imparted which must be neutralized before growing plants can avail themselves of the peaty substance for nourishment. Much of this substance has been derived from the debris of heath, which contains much of the tannin principle; and there is some resin derived from the fir wood, which had been very abundant, as the trunks and roots of the fir tribe still remain to testify, and so completely preserved that even the small fibres can be drawn out entire. Not only plants, but deer and other animals, have been found in peat, which must have been embedded for many centuries, so completely does peat prevent decomposition and putrefaction. But bog earth and swamps are capable of being rendered extremely fertile; the peat marshes of La Vendée are the most productive in the country; the neighbourhood of Amiens yields excellent vegetables; and the name of *marais*, or morass, which the market-gardens of Paris still bear, indicates sufficiently the original condition of the soil. To render peat fertile it is necessary in the first place to drain it, for until the water is removed the air cannot enter the mass, and without oxygen its elements, especially nitrogen, remain unchanged.

When dry, and then exposed to the action of air, moisture, and frost, it is readily pulverized, and loses, in a great measure, its astringent principle; the correction of this is greatly aided by the addition of lime, gypsum, or calcareous marls.

Some kinds of peat will kill the microdemes that cause fermentation, or prevent them from thriving, so that decomposition could hardly occur in presence of any considerable quantity of it. This fact goes far to explain how it is that peat, when used for the bedding of animals or for absorbing their liquid dejections, serves so well to preserve the manure, namely by delaying fermentation.

A valuable compost for garden purposes may be prepared by mixing peat with a little earth and peat ash, and pouring over it now and then stable drainings or other ammoniacal liquids.

The peat used in the cultivation of orchids, ferns, &c., consists principally of the decayed roots, rhizomes, and leaves of bracken. It is therefore quite different in its properties from the peat described above, and is in fact more of the nature of leaf-mould. It is a perfectly safe material to use in the cultivation of all kinds of plants, and the most fibrous quality is preferred to all other material by orchid growers.

Rape-dust.—The oil-cakes are the residues obtained in the process of crushing various seeds for the extraction of oil. They are generally rich in nitrogen, and their value chiefly depends on the amount of this element present, but considerable quantities of phosphoric acid and potash exist in them also, and increase their value as manure. The cake most commonly used in its original condition is rape-cake, which is comparatively low-priced, and is not much relished by stock owing to its bitter taste. When crushed into powder and applied to the soil so as to give 100 lbs. of ammonia per acre, its effect is often greater than that of farmyard manure estimated to contain double that amount. It varies in composition, yielding from 5 to $7\frac{1}{2}$ per cent of ammonia, and $3\frac{1}{2}$ to $5\frac{1}{2}$ per cent of phosphates.

It is especially useful in the garden to hasten the growth of young plants, and as a manure for Onions, Potatoes and root-crops. On many soils its mechanical action is also a recommendation.

Malt-dust.—This consists principally of the radicle and young shoots of barley which has germinated, and which are separated from the malt during the process of malting. It is frequently used as a top-dressing, but it is more advantageous to dig it in, being applied at the rate of from 30 to 40 bushels per acre. It is rapid in its action, and its good effects become quickly perceptible; but it does not form a manure of much permanence. It is a valuable top-dressing for fruit-trees and flowering shrubs in pot culture.

Sea-weeds.—Along the coasts, and particularly the western one, sea-weed is largely used as a manure. For this purpose, during the winter months the weed is drawn from the shore and formed into heaps, lime and earth being laid between every layer of 6 or 8 inches in depth. After remaining in this state for two or three months it is turned occasionally, and when well decayed, is applied to the land before a root-crop, generally Potatoes. Usually sea-weed will contain about 80 per cent of water, 0.2 to 0.4 per cent of nitrogen, from 0.4 to 0.5 per cent of potash, and about 0.3 per cent of phosphoric acid. Sea-weeds are frequently burned, and the ashes employed as a manure. Nevertheless, as the organic matter is destroyed by burning, and consequently much of the fertilizing constituents lost, this practice is not to be recommended.

Green Manures.—Plants are sometimes grown by the farmer specially for the purpose of being ploughed into the land, when they are in a

green and succulent state, as manure. This practice is seldom, however, adopted in gardens, or indeed wherever the soil is in a high state of cultivation. There is, however, a class of green manures which are most extensively employed in gardens. These consist of Potato haulm, the dressings of Cabbages, Turnips, and all superfluous or decaying vegetables, such as are not required for carrying on the growth of the plants, and which are occasionally dug in when in a fresh state; in general, however, it is much better to make them up into a compost, and decompose them previous to applying them to the soil.

The following table will show what amount of fertilizing ingredients is added to the soil if one ton of each of these unmarketable products is dug in as green manure. On the other hand, the figures show what the soil would lose if these products, which have derived their elements mainly from the soil, were entirely removed from the garden.

Selected Constituents in 1 Ton of Various Unmarketable Products—termed "Garden Refuse".

	Potato Haulm	Pea Haulm	Bean Stems.	Carrot & Turnip Leaves.	Cabbage Stems & Leaves.
	lbs.	lbs.	lbs.	lbs.	lbs.
Organic matter, ...	511	1882	1925	403	246
Mineral matter (ash)	14	97	90	54	35
Nitrogen, ...	14	23	16	11	5
Constituents in the ash—					
Potash, ...	10	22	29	6	13
Soda, ...	1	4	7	11	3
Lime, ...	14	36	25	18	6
Magnesia, ...	7	8	6	2	1
Phosphoric acid,	4	8	9	2	3

The data thus given shows how very important it is that all garden refuse, that is unsaleable or cannot be used, should be returned to the soil.

Gardeners and fruit-growers fully recognize the value of farmyard manure. In a ton of ordinary manure there is found 1275 pounds of organic matter, 225 pounds of mineral matter (ash), and 10 pounds of nitrogen. The ash will give 12 pounds of potash, 39 pounds of lime, and 6 pounds of phosphoric acid. Except for its mechanical and indirect benefit to the soil, all the manurial value of this 1275 pounds of organic matter is due to the nitrogen which the dung contains. Garden refuse in many cases contains more nitrogen than medium-quality dung, but at the same time it has to be remembered that the nitrogen in the animal excretions which is incorporated with the dung is in a

more readily assimilable form for plants than the nitrogen in the garden refuse.

If we proportion our supply of manure to the waste caused by the growth and removal of vegetation, we shall keep up the fertility of the soil to the degree in which we found it; if we give more judiciously, we gradually increase the fertility. These principles should be kept in view in the practical application of manures, and if experience confirms their truth we shall have obtained a clearer insight into the mode in which different kinds of manures assist vegetation, and increase fertility in the soil we cultivate.

Soot.—This substance consists principally of charcoal, but its efficiency as a manure is chiefly attributable to its containing ammonia, the amount of which varies in different samples from 1 to 5 per cent. Dr. Voelcker found $3\frac{1}{2}$ per cent of ammonia, $2\frac{3}{4}$ per cent of alkali salts, 11 per cent of carbonate of lime, and 2 per cent of carbonate of magnesia in a sample of commercial soot.

Soot should be kept dry till required for use. It is generally applied as a top-dressing; and it may be scattered at the rate of 30 to 50 bushels per acre; but it is best to apply it as a liquid manure. When used in the latter way it may be mixed in the proportion of 1 peck to 30 gallons of water, and should be allowed to stand till the liquid is clear. It may thus be given once or twice a week with great benefit to growing plants, especially those in pots. As a preventive to the attacks of insects, half a peck of soot and a quarter of a peck of quick-lime, mixed well with water and allowed to stand till clear, form a useful wash. As a top-dressing to pastures and lawns, soot is very beneficial; if raked into the soil with Turnip or Cabbage seed, it forces quickly the young plants into the rough leaf, an object of great importance, inasmuch as when this is the case the ravages of the "fly" are in a great measure prevented. This manure has likewise been employed for Potatoes, and Vine borders and Roses, with good results. It is also used for Onions, raked in with the seed, partly as a manure, but more especially for the purpose of preventing the attacks of the Onion-grub. Asparagus, Peas, Beans, and a variety of other vegetables are benefited by a liberal application. Plants in pots, particularly Pines, when watered with it assume a deep healthy green, and grow strong and luxuriantly.

Blood.—In its natural state blood contains from $2\frac{1}{2}$ to 5 per cent of nitrogen, and when

dried from 6 to 14 per cent. The ash is rich in alkaline phosphates, as exhibited in the following analysis, which possess high fertilizing properties.

The ash of blood contains—

Sodium phosphate, ...	16.77
Calcium and magnesium phosphates, ...	4.19
Oxide and phosphate of iron, ...	8.28
Sodium chloride (common salt), ...	59.34
Potassium chloride, ...	6.12
Calcium chloride, ...	3.85
Calcium sulphates—gypsum, ...	1.45
	100.00

Dried blood is a concentrated source of nitrogen, which yields ammonia by gradual decomposition in the soil; it is, however, hardly sufficiently soluble for most purposes. It may be used for Turnips and Potatoes, and is an excellent manure for fruit-trees. When mixed with earth it forms a rich compost.

Petermann, in Belgium, has carefully tested the fertilizing power of dried blood, as compared with that of nitrate of soda, upon spring Wheat, both on a clayey and a sandy soil.

	<i>Clayey Soil.</i>		<i>Sandy Soil.</i>	
	Grain.	Total Crop.	Grain.	Total Crop.
No manure, ...	7.94	26.13	2.08	7.34
As dried blood, ...	19.56	62.07	5.05	15.75
As nitrate of soda, ...	20.14	64.39	7.51	27.02

Nitrate of soda is seen to be superior to dried blood, especially on light soil. In the opinion of some observers, the nitrogen in blood is worth twice as much per pound as that in coarse bone-meal.

Fish guanos.—These manures are by-products of the large fish-curing factories. The fish refuse is first pressed under heat to extract the oil, and is then reduced to fine powder. Containing as they do a high percentage of ammonia, combined with a fair proportion of phosphates, these fish manures form very valuable fertilizers.

Dr. Voelcker gave the following as the composition of two samples of dried-fish manure:—

	I.	II.
Moisture, ...	14.31	13.87
¹ Organic matter and water of combination, ...	53.80	46.91
² Phosphoric acid, ...	6.05	7.38
Lime, ...	11.27	14.48
Iron oxide, alumina, magnesia, &c., ...	11.43	12.22
Insoluble siliceous matter, ...	3.14	5.14
	100.00	100.00

	Per Cent.		Per Cent.	
¹ Containing nitrogen, ...	I.	8.06	II.	6.62
Equal to ammonia, ...	I.	9.79	II.	8.04
² Equal to tricalcium phosphate, ...	I.	13.21	II.	16.11

The best method of using fish in the raw condition is to make them up into a compost with earth, turf, and other matters; in this way the manure can be more equally distributed, and plants will not then be liable to injury from the roots coming in contact with large quantities of decomposing matters.

Woollen Refuse and Shoddy.—These are waste materials from woollen and cloth mills, and are used to a certain extent in the manufacture of manures. The more finely divided the material the more readily will it decompose in the soil, and the more evenly can it be distributed. Hence, if the amount of nitrogen contained in the materials were the same, shoddy or shredded wool would be better for the gardener than rags; and flocks, which are rags ground to fine powder, would be better still. The nitrogen they contain varies from 5 to 10 per cent, and their manurial effects extend over two or three years.

Horns and Hoofs.—In the impure state in which these are used as manure they contain from 12 to 14 per cent of nitrogen, and, as they decompose slowly, at least when the fragments are large, they form a good fertilizer for Roses, fruit-trees, and Vines.

In order to test the value of organic nitrogen as manure, experiments were made in Germany by Seyffert upon Kohl-rabi; these were so arranged that the plants should be well fed and subjected to like conditions, except that they received different kinds of nitrogenous food. The manurial applications and the amount of crop obtained are as follows:—

Manured with	Weight of Crop in Grammes.
No nitrogenous fertilizer, ...	76
25 grams nitrogen in bone-meal (steamed), ...	1572
„ „ dried blood, ...	1654
„ „ horn-meal (steamed), ...	2005
„ „ nitrate of soda, ...	2608

These results show that the nitrogen in dried blood, bone and horn meal were specially favourable for the growth of plants, although not equal to the same amount of nitrogen when applied in the more soluble form of nitrate of soda.

Bone Manures.—Bones, in some form or other, formed almost the first artificial manure used to any considerable extent in this country. Formerly they were used coarsely broken or crushed in the form of inch-bones, or sometimes half-inch bones, but gradually it has become the custom to use them more finely ground; quarter-inch bones, bone-meal, and bone-dust being now the most common forms of application to the soil.

Bones are an excellent garden manure, especially for fruit-trees, Vines, foliage stove plants, Chrysanthemums, Fuchsias, &c. They are less likely than almost any other manure to waste in wet seasons, particularly on sandy soils, or to be wasted away by artificial waterings in pot culture. On land subject to “fingers and toes” or “anbury” bone manures will be found preferable to superphosphates for root-crops and the Cabbage family. An example of the different effect of coarsely or finely ground bones is given in the *Journal of the Royal Agricultural Society*, by Hannam, who found that an experimental plot dressed with finely-crushed bones produced a crop of about $10\frac{3}{4}$ tons of Turnips, while the same amount of coarsely-ground bones applied to another plot of the same area yielded only about $7\frac{3}{4}$ tons. The soils on which bones produce the best effect are dry ones, and more especially those that are deficient in lime; these manures are considered unsuitable for wet soils. Soils rich in decomposing organic matters, such as leaf-moulds, are greatly enhanced in value by an admixture of bone-meal.

From determinations made by Voelcker it appears there are wide variations as to solubility among different kinds of bone-meal. The phosphate in meal from hard bones, even when very fine, is less soluble than that from porous, spongy bones. The fat of raw bones hinders their solution, and their decomposition also. Putrefying bone-meal is more soluble than that which is fresh. Certain soluble organic matters and ammonium salts that are formed during the decay of bone-meal promote the solubility of the phosphates that are contained in it.

Night-soil.—Analysis shows that fresh human excrements are richer in fertilizing matters than those of farm animals. The food of man is usually much more concentrated than that of animals. It is richer in respect to nitrogen and phosphates, consequently the excrements derived from such food are correspondingly concentrated and valuable for the growth of plants.

According to Wolff, the average percentage composition of human excrements is as follows:—

	Water.	Organic Matter.	Nitrogen.	Phosphoric Acid.	Potash.	Lime.	Magnesia.
Fresh human fæces,	77.2	19.8	1.0	1.10	0.25	0.62	0.36
Fresh human urine,	96.3	2.4	0.6	0.17	0.20	0.02	0.02
Mixture of the two,	93.5	5.1	0.7	0.26	0.21	0.09	0.06

Ordinary night-soil does not contain so large a proportion of fertilizing matters as fresh excrement, being mixed with water, ashes, soil, and other rubbish. It should be deodorized before it is employed in the garden by mixing it with charcoal dust, gypsum, dry earth, sifted ashes, and quicklime.

Night-soil forms an excellent manure for Turnips, the Cabbage tribe, and Celery, and indeed for many other crops, though it is not so much employed as it deserves to be, perhaps on account of its being erroneously supposed to affect the flavour of the plants. In Belgium, France, and many other continental countries, night-soil is highly valued as a manure.

Poudrette.—In some of the large towns of France, Germany, and America, night-soil is dried and made into a transportable form, and sold under the name of “poudrette”; but as it is prepared by adding largely such materials as gypsum, ashes, earth, peat, saw-dust, &c., the mixture forms but a poor fertilizer, and is rarely worth the price asked for it.

Sewage Manure.—Many processes have been devised for the treatment of sewage from large towns, so as to collect its manurial constituents into a portable and saleable form. Dr. A. B. Griffiths says none of these methods is altogether satisfactory, although what is known as the A B C process is considered by some to be “a hit” in the right direction. The A B C process consists in precipitating the manurial constituents by the addition of clay, alum, blood, charcoal, &c., to the sewage. The precipitate so obtained, after drying, constitutes a manure sold under the name of “native guano”. The very best sewage manures are rarely worth more than £2 per ton.

Guano.—The word guano, derived from the Spanish word *huana* (dung), is a term applied commercially to all faecal deposits of birds and marine animals which on different parts of the earth's surface have been collected together in greater or less purity. The quality and value of these manures depend almost wholly upon the amount of decomposition to which they have been subjected by the action of the atmosphere. The faecal matter of these animals consists essentially of nitrogenous and phosphatic compounds. The ammoniacal portion of these deposits, with some of the phosphates, are, through the long-continued action of rain and air, made tolerably soluble in water, and are readily washed away. The phosphates of lime and magnesia are less soluble. In dry climates, where very little rain falls, as in some parts of Bolivia and Peru, on

the western coast of South America, the dung deposited suffers very little from the action of the atmosphere, and retains nearly the whole of its soluble fertilizing compounds. Guanos found in the regions where much rain falls lose a great portion of their soluble ingredients. The residue is, however, often left rich in phosphates of lime and magnesia. Many guanos are also much deteriorated by large quantities of sand being driven on to the deposits by the action of the winds. The composition of the present Peruvian guano is greatly inferior to that of twenty years ago. Average samples contain from 5 to 8 per cent of nitrogen, and from 20 to 35 per cent of phosphate of lime.

The guanos of commerce may be classified under two heads:—(1) Nitrogenous guano, of which Peruvian is a type; (2) Phosphatic guano, of which the Bolivian is an example.

Bats' or Texas Guano.—This manure is imported from Texas, where it accumulates in considerable quantities in caves frequented by large numbers of bats, of which it is the dried excrement. A microscopic examination shows the remains of their insect diet. According to Dr. Voelcker's analysis, bats' guano contains nitrogen in three separate forms—as organic matter, as ammonia salts, and in the form of nitrates. Hence the nitrogen is in different degrees of solubility. The nitrates are ready for immediate absorption by the roots of plants. The ammonia salts may first of all undergo a change, with the ultimate formation of nitrates; and, lastly, the organic matter requires time for its decomposition; therefore it forms a reserve or latent supply of nitrogen, which becomes active after a time.

Dr. Voelcker gives the following as the composition of good-quality bats' guano:—

Water (loss at 212°),	...	...	...	20.10
(1) Organic matter and combined water,	...	...	...	50.13
(2) Phosphoric acid,	...	...	...	6.37
Lime,	...	...	...	12.19
Iron oxide, alumina and alkali salt,	...	...	...	8.58
Insoluble silica,	...	...	...	2.63
				100.00
(1) Total nitrogen (including 2.56 nitric nitrogen),	...	...	...	8.45
Equal to ammonia,	...	...	...	10.26
(2) Tribasic phosphate,	...	...	...	13.90

Guano should always be mixed with six or eight times its weight of fine earth or loam, or with ashes or charcoal dust, or with charred peat, previous to being applied to the soil. Mixed in this way it may be used at the rate of 4 or 5 cwts. per acre.

Guano is also employed with great advantage

in a liquid form. Half an ounce of guano to a gallon of water is considered to be a safe proportion for all plants; and it will be a safer course to repeat the dose of this weak solution rather than to increase its strength.

Dung of Poultry.—The dung of fowls is a manure somewhat analogous to guano, though far less valuable than that material, weight for weight. To begin with, the food of hens, pigeons, ducks, and geese is of vegetable rather than of animal origin, while the sea-fowl that produced the guano lived upon fish, and consequently voided a more highly nitrogenized excrement, and, moreover, the guano has become highly concentrated by the peculiar processes of slow decay to which it has long been subjected.

Selected constituents in one ton of poultry dung, in one ton of farmyard manure, and in one ton of guano.

Excrement of—	Nitrogen.	Potash.	Lime.	Phosphoric Acid.
	lbs.	lbs.	lbs.	lbs.
Hens, ...	43	19	58	39
Pigeons, ...	47	25	44	41
Ducks, ...	27	13	23	31
Geese, ...	15	21	13	12
Farmyard Manure,	10	12	39	6
Peruvian Guano,	156	67	269	314

Since poultry manure is apt to be sticky when fresh, and lumpy when dry, it is not particularly well fitted to be used in the garden as a concentrated fertilizer, and it may consequently well be relegated to the compost heap, as a general rule. It is to be observed, however, that much of the nitrogen in the dung of fowls is in the form of uric acid, a substance directly assimilable by plants, and easily converted into oxalate of ammonia by putrefaction. The foregoing data show how much richer poultry manure is in plant-food than ordinary farmyard manure, and that it must be largely diluted with soil or other materials before being put upon the garden, otherwise the plants to which it is applied will be burnt up.

Poultry manure is a valuable fertilizer, although it differs, as shown above, very considerably from guano in that it has never been concentrated and, so to say, purified, by the slow processes of fermentation to which the guano beds have been subjected.

Dungs differ as Animals do.—It hardly needs to be explained that each kind of manure has its own characteristics and peculiarities, in consonance with the fact that each kind of animal has its own way of utilizing and of rejecting food. There are, naturally enough, says Storer,

as wide differences between the excrements of dogs and cows as there are between the structure, kinds of food, and habits of life of the two animals. In any event, the dung of flesh-eating animals—that of cats, for example—will manifestly be richer in nitrogen, and sometimes in phosphates also, than that of grazing animals. The same reasoning will apply to the mixed feeders, and it is true in fact that the excrements of men, and swine, and poultry are held to be more valuable than those of grass-eating animals. It is noteworthy, by the way, that the French and German cultivators who are accustomed to pasture swine, or to feed them upon very thin wash of one kind or another, hold hog manure in comparatively small esteem. It is only in England, where hogs habitually get grain or milk to eat, that their manure is thought to be worth much.

The kind and quantity of litter used for the bedding of animals affects the value of the manure as employed for the garden very considerably, and this influence depends, first, on its chemical composition, in so far as the litter contains nitrogen, potash, phosphoric acid, &c., which add to the amount of plant-food in the soil.

The following table shows the amount of the most valuable constituents in certain materials commonly used as litter for farm animals:—

Percentages of certain Constituents of Litter.

	Nitrogen.	Phosphoric Acid.	Potash.
Wheat straw, ...	0.48	0.23	0.49
Barley straw, ...	0.48	0.19	0.93
Oat straw, ...	0.40	0.28	0.97
Pea haulm, ...	1.04	0.38	1.07
Potato haulm, ...	0.50	0.10	0.30
Heather, ...	0.90	0.10	0.40
Fern, ...	2.40	0.45	2.42
Rushes, ...	0.40	0.35	1.67
Beech-tree leaves, ...	0.80	0.24	0.30
Peat, ...	1.50	trace.	0.10

Urine as a Manure.—The nitrogen in mere dung is very inferior in quality to that in urine, since most of it is insoluble and in a condition unassimilable by plants. It is contained chiefly in the undigested, not to say indigestible, portions of food which have been expelled by the animal as useless for his purposes, while the nitrogen in urine is all in solution, and in a condition fit to be immediately taken up by plants.

Urine, before being applied to garden plants, should be allowed to putrefy; it should then be largely diluted with water, or mixed with soil or other substances, so as to form a compost; for, when used in an unmixed state, it is very

injurious to tender plants. To fruit-trees, Raspberries and Currants, kitchen-garden crops, and flowering shrubs, the application of urine proves highly beneficial.

From the facility with which it can be applied to growing plants, without disturbing their roots, as well as on account of its rich manuring properties, urine is an excellent manure for garden purposes.

Liquid Manure.—Almost any manure may be applied to the soil in a liquid state, consequently all such might be included under this heading; nevertheless, as, when speaking of each manure, the circumstances of its being used in a liquid form have been mentioned, we shall confine ourselves to the common acceptance of the term liquid manure.

Liquid manure is generally considered to imply the drainings of dung-heaps, stables, cow-houses, and piggeries; and it consists chiefly of urine, together with more or less of the solid excrements of the animals dissolved by it, or by rain-water. Collected from such various sources, it is evident that the composition and value of liquid manure must vary considerably, according to the kind of animal from which it is derived, the amount of solid matters it contains, the mode of preserving it, and other circumstances.

Liquid manure is used with excellent effect for Pine-apples, Cucumbers, Tomatoes, fruit-trees, and flowering shrubs of all kinds, both in pots and in the open ground, Strawberries, and, in short, for all plants in pots that require to be stimulated. When it can be had in sufficient quantity it is beneficially applied to Vine and Peach borders, and to kitchen-garden crops. In using it, however, care should be taken that the soil be not over-saturated with it, for in that case it is worse for the growing roots than saturation with common water. It is a safe plan to water plants with liquid manure and rain-water alternately.

Horse-dung.—The solid excrements of the horse consist of 20·67 per cent of organic matter, 4·02 per cent of mineral ingredients, and 75·31 per cent of water. Horse-dung is most beneficially applied to cold, stiff soils; and in order that its mechanical action may be turned to advantage, the dung should not be much decomposed, care being taken, however, that the litter is sufficiently moist for decomposition, without becoming musty in the ground, as it does sometimes in dry weather when it is not previously well saturated.

Of equal weights of horse-dung and cow-dung, the former is the more fertilizing; but taking

bulk for bulk of each, it is inferior to cow-dung. Where horse-dung is not applied particularly for the purpose of keeping the ground open, but merely for its manuring properties, it should be previously turned, and during the process it should be well moistened, preferably with the drainings of the farm-yard or other liquid manure. Fermentation is apt to become excessive in the heap of horse-dung, and then it is injurious, for the ammonia is driven off, and the littery portion in the centre is apt to become dried up and rendered inert. Means should therefore be adopted to prevent the heat from becoming too great; the heap should be turned, spread out, or watered, before it becomes too hot; and the ammonia, that would otherwise escape, may be absorbed by a covering of soil or turf, or any substance, in short, that is found to prevent the heap from exhaling effluvia. Horse-dung is well adapted for producing immediate action on crops; hence, for such of these as are required to be produced as early as possible, it is well to manure with the droppings shaken from the litter.

Cow-dung.—According to Boussingault, 100 parts of fresh cow-dung contain 8·27 parts of organic matter, 1·13 part of mineral ingredients, and 90·60 parts of water. Cow-dung contains more water than horse-dung, and a smaller proportion of nitrogen. Its fertilizing properties are inferior to those possessed by horse-dung, and from its not readily fermenting, it is colder than that manure. It is slower in its action than horse-dung, but its effects are much more lasting; it is, therefore, better adapted for trees, or any crop that requires the manure to continue for years. For hot dry soils it is better adapted than horse-dung; but, on the contrary, it is not proper for cold and wet soils, and to such, more especially, it should not be applied in spring, or, at all events, it should not then be employed in its crude wet state. Mixed with horse-dung, or with litter, and the whole slightly fermented, it answers better for damp heavy soils. Some have used large quantities of cow-dung in forming borders for Vines and for other fruit-trees, but experience has proved, that after two or three years the mass of cow-dung becomes inert, and retains too much moisture in winter. For fruit-trees generally, a compost of cow-dung and good turfy loam is found preferable to cow-dung alone.

There is perhaps no kind of manure that retains moisture so well as cow-dung. It is, therefore, excellent for dry hot soils, and as a mulching over the roots of trees; yet in a fresh unfermented state it will injure the roots of some plants if they come in contact with it where it

may happen to be unmixed with soil. By fermentation it is rendered safe for vegetation.

Pig's-dung.—Fresh pig's dung, consisting of the excrements and urine, contains, according to Professor Solly, 93 parts of dry organic matter, 87 parts of mineral ingredients, and 820 parts of water. This manure contains more nitrogen than horse-dung, and is considered as powerful as night-soil. In an unmixed state it is too strong for vegetation; but when mixed with litter and as much earth as will moderate fermentation, it becomes an excellent manure. By throwing in weeds where the pigs can search them over, and which they will not fail to do very assiduously, the portion which they reject is formed into manure of considerable strength. But when weeds enter thus into the composition of manure, it is absolutely necessary that the whole should be thoroughly fermented, otherwise the seeds will germinate, and render the ground manured very foul. When seeds are exposed to moisture, and a degree of heat equal to that which is required for inducing vegetation, they must either grow or rot; they will attempt to vegetate, but, stimulated by heat and moisture, and at the same time deprived of air and light, they will soon die. At and near the outside of the heap, seeds may exist cool and free from excitement, and consequently their vegetative powers will be preserved, to produce in due time a crop of weeds, after being transferred, along with the manure, to the ground. It is, therefore, advisable that the manure should be turned after fermentation has gone on so far as to kill all seeds in the interior of the heap. The outside or other cool portions should then be carefully turned inwards, where they will be most subject to the effects of fermentation. By adopting this plan, weeds may be turned to account by partly feeding the animals, and by forming a bulk of manure of that which they refuse to eat. The strength of the manure will, of course, be lessened in proportion to the quantity of weeds and adherent earthy matter introduced; but if no more of these be thrown to the pigs than they can thoroughly moisten, the resulting manure will be strong enough for ordinary garden crops.

Pig's-dung, free from litter or other matters, is employed with very beneficial results in forming with turfy loam a compost for Pine-apples.

Farmyard Manure.—By this is generally understood the manure produced by horses, cows, or other cattle kept on the farm. It may be that of one kind of these animals, or it may be composed of a mixture of the excrements of several.

When the excrements of the several kinds of animals are kept separate, their properties can be ascertained by referring to what has been stated respecting the dung of each, and therefore they need not be here further noticed. But, unless for particular purposes, which may render it desirable to use the dung of one kind of animal in preference, it is in general better that the dung of horses and that of horned cattle, &c., should be mixed. When this is the case, plants can obtain with greater certainty the various elements which they require for their nourishment. The best farmyard manure is accordingly formed by mixing together the excrements, both solid and liquid, of the different animals. The liquid portion cannot be better nor more economically employed than by being soaked up by the litter, so that the latter may have, in consequence, moisture enough to allow of its decomposition by a slight fermentation, instead of being dried up and for some crops rendered worse than useless.

With many it has been, and is still a question, whether farmyard manure should be applied to the soil without the least previous fermentation. But we are convinced that manure is rendered a much readier and better source of food for plants by being judiciously fermented before it is applied to the soil. At the same time we admit, and would strongly urge, the necessity of guarding, as much as possible, against the dissipation of its volatile fertilizing principles by violent fermentation. When manure is slightly fermented, it produces a more immediate effect than when it is applied fresh. Vegetable fibre, which constitutes a large proportion of the bulk of farmyard manure, decomposes but slowly when introduced without previous fermentation into the soil, and until such time as it does become decomposed, it affords no nourishment to plants. Its presence in that insoluble state may do good in certain soils that require to be kept open, especially at a particular period of the season. Moderately fermented farmyard manure, composed of the dung of various kinds of animals, and which likewise contains as much as possible of their urine, is most proper for garden soil that has been duly prepared and reduced to a proper texture.

Composts are mixtures of various earths or manures. Their number may be said to be infinite, and they are of the greatest utility in horticulture. Many manures, of which only small quantities are necessary, require to be mixed with other substances in order to ensure their even distribution; others, again, are so powerful, that in an unmixed state, instead of

proving beneficial to vegetation, they would be actually destructive to it, as has been pointed out with reference to guano, &c.; all such are advantageously formed into composts.

Lime should never be used in composts with animal matters in the decomposition of which large quantities of ammonia are formed. With weeds, and the roots, leaves, and stems of plants, excellent composts may be formed, and the use of lime in this case is not objectionable, more especially as it rapidly destroys vitality. Another excellent mode of economizing all such vegetable refuse is to thoroughly rot it in liquid manure, and this can hardly be applied to a better purpose.

Flesh, hair, feathers, the refuse of sugar-refineries, pond-mud, ditch-scourings, and numerous other kinds of animal and vegetable refuse, the names of which alone it would be tedious to enumerate, may all be advantageously employed as manure. In general it is most economical and convenient to make such substances up into composts with earth, urine, and other matters.

II.—INORGANIC MANURES.

Coal Ashes are useful as manure on certain kinds of soil, and are found to encourage the growth of Peas and Beans. When mixed with bones, night-soil, guano, blood, or other substances rich in nitrogen, they form a good manure. It is more especially upon stiff clays that coal ashes are found beneficial, and on such they tend to loosen the soil. The value of coal ashes is almost entirely due to the sulphate of lime or gypsum which they contain in variable quantities.

Peat Ashes are very variable in their composition, according to the localities from which they are brought. In some cases these ashes are principally composed of carbonate of lime; whilst in others they contain a considerable amount of the phosphate and sulphate of lime, and are of considerable value, as in the case of Dutch ashes, which are much esteemed in Holland as a manure for Turnips and Clover.

Peat ashes are usually applied as a top-dressing, at the rate of 20 or 30 bushels to the acre.

Wood Ashes form a valuable manure, always containing potash and soda, besides other inorganic elements of the food of plants. Wood ashes are exceedingly well adapted for mixing with guano or dung. They are also an excellent manure when applied by themselves. Of course they will not supply the want of organic manure. A bushel of wood ashes will weigh about 50 lbs., and contains potash and soda, 4·6 lbs.;

phosphoric acid, 1·47 lb.; hydrochloric acid, 1·22 lb.; magnesia, 1·96 lb.; lime, 21·77 lbs.; sulphuric acid, 0·43 lb.; iron oxide, 0·21 lb.; manganese, 0·41 lb.; carbonic acid, 17·12 lbs.

An excellent substitute for wood ashes may be obtained by mixing together: Muriate of potash, 9 lbs.; phosphate of lime, 6 lbs.; and slacked lime, 35 lbs.

The roots of plants, weeds, &c., are frequently burned, and their ashes applied to the soil; but as all the organic matter and nitrogen is lost by this means, the practice is not to be recommended. It is far more economical to form them into a compost with earth and quicklime, or other substances, to destroy their vitality. After they have been thoroughly decomposed and brought to the state of vegetable mould, they are excellent for horticultural purposes.

Charcoal forms a valuable auxiliary to manures, and even when applied to the soil without the admixture of manuring substances, it has great fertilizing properties. Its action, in either case, is almost entirely due to its well-known property of absorbing ammonia, carbonic acid, and other gases, and again giving up these substances for the nourishment of plants; for, as far as the carbon of the charcoal is concerned, that yields no food to plants. There is no doubt, however, that the mineral matters contained in charcoal, as usually prepared, contribute in some measure to its fertilizing effects. It also renders the soil to which it is applied in any considerable quantity lighter and more friable. Another circumstance worthy of remark is, that charcoal, by darkening the colour of the soil, increases the power of the latter to absorb heat—a point of no small importance. Charcoal forms an excellent mixture with guano and other artificial manures, in order to secure their more even distribution. When so employed, it not only answers this purpose, but, from its power of absorption, prevents the escape of the ammonia when more of this is liberated than can at once be absorbed by the soil, or by the roots of plants. By reason of this property it forms an excellent covering for manure heaps, and prevents all bad smell. When applied by itself it has been found to produce very beneficial effects on Turnips and Carrots.

Ashes of Burned Clay.—Burned clay is extensively used in the heavy lands of Essex, Suffolk, and elsewhere, and the practice is attended with great success. The beneficial action of burned clay is chiefly due to its altering the texture of the soil, rendering this less compact, and consequently more permeable to air, water, and the

roots of plants, and to the burned clay containing a much greater proportion of soluble alkalies, more especially of potash and soda, than the unburned clay, a considerable portion of the alkaline substances contained in the latter being rendered soluble in the process of burning. Burned clay, by improving the texture of the soil, and by supplying a greater amount of alkalies to plants, must prove beneficial to all crops; but it is more especially on Turnips, Carrots, and Potatoes, fruit-trees, or other plants requiring a large amount of potash, that the beneficial effects of this manure are most conspicuous.

The state to which the clay is reduced by burning is of great importance; for if exposed to too great a heat, it will become of the nature of brick, and its alkaline ingredients will be less soluble than if burning had not been resorted to. The clay should only be slightly burned, and so that it may readily crumble down. The effect of burning is to get rid of all the organic matter, but the mineral constituents which plant-life had abstracted from the soil remain, and they are so transformed by fire as to be easily assimilable by future crops.

The following is Sir H. Davy's analysis of the ash of burned turf:—

	Per cent
Carbonate of lime, ...	40
Sulphate of lime (gypsum), ...	5½
Charcoal (carbon), ...	4½
Potash and magnesia, ...	1½
Iron oxide, ...	7½
Insoluble earthy matters, ...	41
	100

Burning has really very much the same effect that liming has in sweetening the soil, and in setting free quantities of inorganic matter which were previously in a locked-up or inert condition.

Gas Waste.—The ammoniacal liquor obtained in making gas is employed as a manure, and with good effects. It consists of a solution of the carbonate, hydrosulphate of ammonia, and other salts of the same base. All its value is due to the ammonia which it contains; the amount of this is subject to considerable variation, but rarely exceeds 2 per cent. On account of its caustic nature, gas water should always be applied with caution, and it should be diluted with five or six times its bulk of water, otherwise it is certain to burn up whatever crops it is applied to.

Gas water is chiefly applied to grass, and may be used at the rate of from 100 to 200 gallons per acre. Field Cabbage, and any of the Cab-

bage tribe, in a garden will be greatly benefited by an occasional watering with gas liquor, as will also Raspberries and Black-currant trees, but, for the reason previously given, it must be diluted with water. This, of course, involves a considerable amount of labour; and it may be observed, that the practice is only applicable to light soils.

Gas lime is the lime which has been employed in purifying the gas, and it always contains a large quantity of the sulphuret of lime, the action of which on vegetation is unquestionably injurious. For this reason, the use of gas lime in a fresh state as a manure is not to be recommended. After long exposure to the action of the air and water, the hydrosulphuret of lime is converted into sulphate of lime or gypsum, and its injurious action ceases. Gas lime is then merely a mixture of gypsum and lime, and is usually free of injurious compounds, and a manure which, if dug into the soil during winter, will be found beneficial in preventing club-foot, and the disease known as "fingers and toes" (Anbury) in the Cabbage family.

Gas tar consists almost entirely of carbon and hydrogen, and is of little or no value as a manure, though it has been occasionally used as such.

Lime has long been employed as a manure, and its application to the soil has been attended with great success, especially when preceded by drainage. Lime does not occur in nature in a free state, but united with carbonic acid, forming carbonate of lime, it is found in abundance. There are many varieties of carbonate of lime, but the most common are limestone and chalk. Pure carbonate of lime consists of 56·3 per cent of lime and 43·7 per cent of carbonic acid. On being exposed to a strong red heat, carbonate of lime loses its carbonic acid, and *quicklime* is produced. This substance has a powerful affinity for water, absorbing it rapidly when brought in contact with it, and more gradually when exposed to the atmosphere; in both cases, a compound of the hydrate of lime, consisting of 28·5 parts or 1 equivalent of lime, and 9 parts or 1 equivalent of water, is produced.

The process by which the hydrate is formed is called *slaking*, and it is always attended with a great increase of temperature. The hydrate itself is termed *slaked lime*. After long exposure to the air, the hydrate of lime parts with its water, absorbs carbonic acid, and again becomes carbonate of lime.

Quicklime is extremely caustic, decomposing all animal and vegetable matters with which it

comes in contact, and causing the formation of carbonic acid, ammonia, and other compounds; hence it is of great utility in fertilizing peats, and all soils abounding in roots and inert vegetable matter, by decomposing the vegetable fibre, and reducing it to a more soluble state.

Respecting the chemical action of lime in the soil, much uncertainty prevails. There is no doubt that lime, by decomposing vegetable matter, contributes to the food of plants by supplying them with carbonic acid, ammonia, &c. Liebig ascribes the beneficial action of lime chiefly to its affording a supply of potash and soda, by decomposing minerals which contain these substances. Lime is itself a necessary element of the food of plants, and its application may in some cases prove beneficial by furnishing plants with an indispensable element of their food; but that would only be in soils deficient in lime. We may therefore conclude, that lime acts more by bringing other substances into a proper condition for being absorbed by the roots of plants, than by affording nourishment of itself. Some soils, especially such as are peaty, become what is called *acid* or *sour*, owing to the presence of vegetable acids; on such soils lime acts as a corrective, by uniting with and neutralizing its evil effects.

Lime in its hot or caustic state is applied with great advantage to soils containing an excess of inert vegetable matter, such as peaty soils and recently broken up grass-land. The roots, fibres, &c., in these cases would long remain in the soil in an undecomposed state, and one in which they could yield no nourishment to plants; but lime, by decomposing and rendering soluble this vegetable matter, reduces it to a state in which it can be taken up by the roots of plants and assimilated.

The addition of lime to clay soils is not only followed by the usual chemical effects produced by the application of lime, but the texture of the soil is also improved. The effects of lime on clays, however, greatly depend on the amount of organic matter which these contain. If the soil is deficient in this respect, lime will chiefly prove advantageous by liberating the alkalies potash and soda.

The quantity of lime that should be applied to an acre of ground varies from 30 to 200 bushels. Where the soil contains much vegetable matter, as in the case of grass-land which has been recently broken up, the larger quantity may be advantageously employed for a first liming. Clay soils require more than light loams or sands; and whenever there is only a small amount of

vegetable matter in the soil, lime should be used only in small quantities, otherwise exhaustion will be the result.

In all cases, it should be remembered that lime will not supply the place of organic manure, and that it merely renders this available for the nourishment of plants. Where the ground has been long manured with farmyard manure, as an old kitchen-garden, for instance, the use of small doses of lime proves very advantageous in hastening the decomposition of the vegetable matter.

In applying lime to the soil, it should be used as a top-dressing, or forked in so as to mix it well with the soil. From the tendency which lime has of sinking deeper and deeper into the earth, it frequently accumulates in the subsoil. If the nature of the latter will permit, the lime may be recovered by trenching it up, and this, in most cases, is preferable to liming afresh.

Lime is very advantageously employed in forming composts with ditch-scurings, earth, weeds, &c., as it hastens the decomposition of the vegetable matter, liberates alkalies, destroys the vitality of seeds, roots, &c., and kills vermin, besides itself contributing to the fertilizing effects of the mixture.

Lime made from magnesian limestone, and containing caustic magnesia, has been found to act injuriously on many soils.

Chalk is a variety of carbonate of lime; besides this substance, it usually contains 4 or 5 per cent of other matters, which generally consist of clay, sand, potash, soda, oxides of iron, phosphoric and sulphuric acids.

Chalk acts both mechanically and chemically when applied to the soil. The principal mechanical effects produced by chalk are the alteration which it produces in the texture of the soil, rendering soils which are light and incapable of retaining a sufficient quantity of moisture more compact and retentive; at the same time, by this change in the texture of the soil rain is prevented from washing away the soluble substances necessary for the support of plants.

All plants contain lime, and it may be concluded that chalk, which is sparingly soluble in water containing carbonic acid, acts partly by supplying this necessary element. It has been stated that chalk generally contains other substances besides carbonate of lime. Of these, phosphoric acid, potash, soda, and sulphur are all necessary to vegetation; and in practice it has been found that the richer chalk is in these, the more beneficial are its effects.

Chalk is useful as an occasional dressing for Vine borders, and for fruit-trees generally.

Gypsum, or sulphate of lime, is a combination of one equivalent of sulphuric acid with one equivalent of lime. In its natural state it always contains a considerable proportion of water, which may be expelled by exposing it to a temperature of 270° ; it then becomes plaster of Paris. One hundred parts of gypsum consist of 32.5 parts of lime, 46.5 of sulphuric acid, and 21 of water. Gypsum is sparingly soluble in water, requiring for solution 500 times its weight of cold, or 450 of boiling water.

Many different opinions are entertained respecting the action of gypsum as a manure. Some chemists consider that it acts by supplying direct nourishment to plants, affording them sulphate of lime, which is found in their ashes.

Gypsum has been applied with considerable success to grass, and more especially to Lucerne, Sainfoin, and Clover. Good results are also stated to have followed its application in the case of Turnips and Potatoes. It is used as a top-dressing, and at the rate of 2 or 3 cwt. per acre, sometimes less, sometimes more. It is found to produce the best effects when sown in wet weather; and in America they are very particular to use it after a shower of rain.

The soils to which it is considered best adapted are light or sandy ones, though it has also been successfully used on heavy soils. The reason why gypsum produces no benefit in many soils is doubtless owing to the fact that lime already exists in them in sufficient quantity, or that they contain too little organic matter for the gypsum to act upon.

Phosphate of Lime.—Inexhaustible beds of phosphorite occur in Spain and Portugal. It likewise exists in large quantities in coprolites, and in bones, the fertilizing effects of which are principally due to the presence of this substance. All organic manures, and some kinds of chalk and marl, also contain phosphate of lime. The better kinds of phosphatic guanos contain a great deal of phosphate of lime of a high degree of purity, and easily dissolved and appropriated by plant-roots.

Phosphate of lime is found in nearly all plants, and, on account of its supplying phosphoric acid, constitutes a valuable addition to all soils.

Coprolites, or the fossil excrements of animals, are found in most geological strata, but more especially in the greensand, lias, and Suffolk crag.

They occur in rounded nodules, generally of small size, which have a stony appearance and brown colour. They consist principally of phosphate of lime, phosphate of magnesia, and carbonate of lime. Some coprolites have been found

to contain as much as 70 per cent of phosphate of lime, but in general the proportion of this substance rarely exceeds 55 per cent. On account of the phosphates of lime and magnesia which they contain, coprolites constitute a valuable manure. They are used either in a ground state, or submitted to the action of sulphuric acid, when they are converted into superphosphate of lime and gypsum.

Marl.—This term is employed to designate various earthy substances, principally consisting of clay or sand, but all containing more or less calcareous matter.

The use of marl as a manure dates from a very early period. Marls may be divided into six principal varieties, namely—1. clay-marl; 2. sandy marl; 3. chalk-marl; 4. slaty or stony marl; 5. shell-marl; 6. peaty marl.

1. Clay-marls are applied with great advantage to all loose and sandy soils, the texture of which they greatly improve by communicating to them the requisite degree of tenacity. Peaty soils are likewise benefited by the application of clay-marl, the lime in which neutralizes the vegetable acids in the peat. The beneficial action of clay-marls is not solely attributable to the alteration which they effect in the texture of the soil they are applied to, for it is partly due to the carbonate of lime they contain, and likewise to their frequently affording a supply of phosphoric acid, potash, and soda, often found in small quantities in clay-marls.

2. Sandy marls consist principally of sand, of which they often contain as much as 70 or 80 per cent. The amount of lime which is present in these marls is also variable. In some it occurs to the extent of 30 per cent; in others it is less than 10 per cent.

Sandy marls greatly improve stiff and retentive clays, the friability of which they much increase.

3. Chalk-marls consist principally of carbonate of lime, and may be applied with advantage to all soils deficient in calcareous matter, and wherever the use of chalk is attended with good effects. Some chalk-marls are rich in phosphate of lime. When this is the case, they are applied with advantage to nearly all soils, even to those which already contain a considerable amount of carbonate of lime.

4. Slaty or stony marls. Of these, some have a gravelly appearance; others, that of indurated clay; some contain a considerable amount of carbonate of lime, whilst others consist principally of sand, with but a small quantity of lime. These marls, when exposed to the action of air, water,

and frost, soon become powdery, and readily mix with the soil. When phosphate of lime is present in marls of this sort, their value is greatly increased; but some of them contain a considerable amount of oxide of iron; and when this is the case, they should be employed with caution, otherwise bad results may arise from their use.

5. Shell-marls consist of the remains of infusorial animals, and of the shells of shell-fish, mixed with sand, clay, and some organic matter, the whole in a finely-divided state. These marls are rich in carbonate of lime, and the organic matter and phosphate of lime which they contain add materially to their value. Shell-marls may be beneficially applied to all soils deficient in calcareous matter, likewise to sour peaty soils.

6. Peaty marls. Marls are occasionally found which contain a considerable amount of peat; these form a valuable addition to soils deficient in organic matter. As they are very wet when first dug up, and retain moisture for a long time, they ought not to be applied in a fresh state. On this account they should either be made up into a compost, or burned; but if the latter method be adopted, the organic matter will be lost, and the marl will merely be valuable for the lime and other inorganic substances which it may contain.

The quantity of marl which should be applied to the acre is entirely dependent on the nature of the soil, and the composition of the marl itself.

Limestone Gravel occurs chiefly in Ireland; it is of the same appearance as common gravel, only of a blue colour, and effervesces briskly with hydrochloric acid. This gravel is sometimes very fine, approaching to marl in its nature. It is used with great advantage on bogs and strong clays; it produces on the latter all the effects of a dressing of marl, greatly increasing their friability.

Calcareous Sands are much employed in some parts of the country, not only for improving the texture of the soil, but also for the sake of the carbonate of lime, which some of them contain to the extent of 60 per cent and more.

In Devonshire and Cornwall, immense quantities of shell-sand—a calcareous sand, consisting chiefly of sand and the remains of shells, together with a little organic matter—are carried many miles inland, for the purpose of applying it to the land. Deposits of shell-sand are likewise found on the west coast of Scotland, and in the Hebrides; also, on the north, south, and south-west coasts of Ireland.

Calcareous sands are of great benefit to all soils deficient in lime; they are also advantageously employed in improving heavy retentive soils, to which they not only supply calcareous matter,

but also improve their texture. Calcareous sands are likewise applied with excellent results to peaty soils, the vegetable acid of which they neutralize.

Some of these sands contain a considerable amount of phosphoric acid and organic matter; when such is the case, they are most valuable fertilizers.

Magnesia is found in the ashes of plants, and is therefore absolutely essential to their growth. In its caustic state it appears to be injurious to vegetation; but one of its salts—sulphate of magnesia, or Epsom salts, a compound of sulphuric acid with magnesia—has been used with some success as a manure for Potatoes, Turnips, and Onions. But since magnesium compounds are found in tolerable abundance in most soils of fair quality, and especially in garden soils which have been largely dressed with stable manure, comparatively little attention has been given to their employment as fertilizers. It is true, indeed, that the amount of magnesia taken up by plants is large, although variable in quantity. Thus, Raspberry canes take up 11 per cent, while the Pear-tree only requires 5 per cent. The ashes of the fruit of the Fig show 9 per cent, while the ashes of the Cherry, Gooseberry, and Green-gage Plum show only 5 per cent. Again, the ashes of Datura flowers show nearly 10 per cent of magnesia, while the Dianthus is satisfied with 4 per cent. And in the ashes of vegetables the Asparagus shows 13 per cent, and the Onion 5 per cent only. It is possible that magnesia, when applied as a manure, may act directly by serving as food for the plant, or it may be that it will act indirectly, by uniting with the aluminous double silicates which exist in the soil.

Phosphate of magnesia is found in bones and other organic manures. The use of these is, doubtless, the cheapest and most advantageous way of supplying magnesia, when we take into consideration the other important and highly fertilizing principles which such manure contains.

Ammonia, from its being the great source from which plants derive their nitrogen, is one of the most important components of manures. To its presence, or formation, guano, the excrements of animals, flesh, blood, &c., owe most of their value as fertilizers. All manures containing ready-formed ammonia exercise a peculiar stimulating action on vegetation, producing a luxuriant and rich dark-green foliage, together with a great increase in the total crop grown.

Ammonia is supplied to plants by the decom-

position of organic matter in the soil, by which, when thus generated, it is retained. It is likewise continually formed in the air by the decay of organized bodies, of both animal and vegetable origin. The ammonia existing in the atmosphere, in the state of a carbonate or nitrate, is soon carried down to the earth by rain and snow, the water of which always contains ammonia and nitric acid. In this way a considerable amount of nitrogen is supplied to plants. Now, though this quantity of nitrogen might be sufficient to supply the necessary amount of nitrogenous food to plants growing in a state of nature, yet it would prove totally inadequate to meet the greatly increased demand induced by cultivation, and to compensate for the large quantity of nitrogen carried away in the crop. To maintain fertility nitrogenous food must therefore be artificially restored to the soil.

The beneficial effects of the practice of allowing land to lie for a considerable time before it was again cropped were partly due to the gradual restoration of nitrogen to the soil by means of rain and other aqueous deposits.

For the reasons before mentioned, ammonia must be supplied to the soil; this is effected either by the use of organic manures rich in nitrogen, or by employing some of the salts of ammonia. The salts of ammonia which are used for this purpose are the sulphate, muriate, and the phosphate. All these are extremely powerful in their action, and immediate in their effects, requiring at the same time to be employed with great caution.

Sulphate of ammonia is the salt most commonly used, and it may be applied at the rate of from 2 to 3 cwts. per acre with perfect safety. If the soil is lacking in available minerals, then an application of superphosphate or potash, or a combination of both, must be added to the ammonia salt. Sulphate of ammonia may likewise be very advantageously employed dissolved in water, as a liquid manure; and in this way it is peculiarly beneficial to growing plants, whether in pots or in the open ground; especial care should, however, be taken not to use a solution of too great strength. Half an ounce to a gallon of water is ample.

Potash is an important part of the food of plants, and is found in large quantities in their ashes; yet in most soils it is only found in small quantities in a soluble state; it is consequently a valuable constituent of manures. Its salts are found in the excrements of various animals, and in most organic manures.

Much of the value of wood ashes, as a manure,

is due to the carbonate and other salts of potash which they contain; and this is confirmed in practice by the beneficial effects which wood ashes produce on Beans, Peas, Potatoes, Turnips, and the Vine, which are all plants that contain much potash.

The value of potash as a manure for Vines is well illustrated by a series of experiments made by M. Ville¹ as far back as 1875, of which we here reproduce the results. The Vines illustrated represent the general average of those grown in each plot of ground. They were taken up and

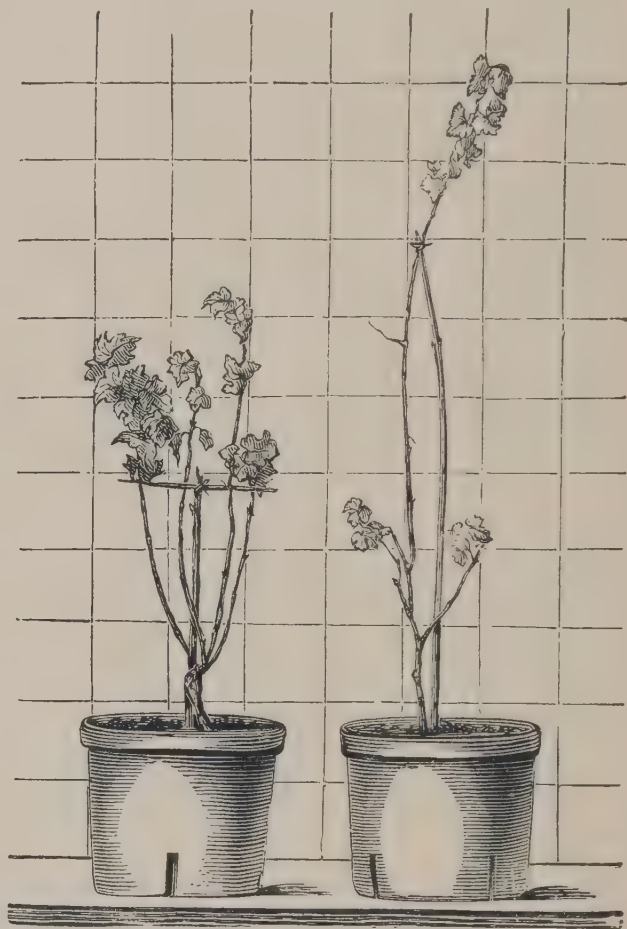


Fig 170.—Vines grown without Manure.

temporarily potted for being photographed. M. Ville grew Vines without any manure for comparison. On this plot of land two Vines gave only a few shrivelled grapes; in fact the crop might be counted as nothing.

On the next plot grapes were grown with a manure from which potash only was withheld, and a singular result was obtained, there being no fruit.

M. Ville says: "In the case of the Potato the suppression of potash manifests itself by a diminution of the crop: with the Vine, however, little or no fruit makes its appearance, and we virtually get no crop at all. The Vine itself barely sends forth two or three feeble shoots, and the few shrivelled leaves are hardly as large as a crown piece, while those of the plants which

¹ *Artificial Manures*, by M. George Ville, translated and edited by W. Crooks, F.R.S. London: Longmans & Co. (1879).

were dressed with normal (complete) manure developed as large as a man's hand."

In the plot of land without potash, as early as the beginning of the month of June, the Vine leaves turn red and then black, drying up and shrivelling like those of Potatoes which have received the same treatment.

When M. Ville tried a manure which contained potash and all other necessary elements, with the exception of nitrogen, he obtained a yield of grapes weighing 2 tons 10 cwt. per acre.

In the case of a manure which contained nitrogen, potash, &c., but from which phosphate was absent, the following result was obtained, viz. 2 tons 18 cwt. of grapes per acre.

These experiments showed conclusively that potash was the most essential element of plant-food for Vines, nitrogen standing second in importance, and phosphate third.

When lime only was omitted from the manure, the yield of grapes obtained was 3 tons 2 cwt. per acre. Lime, therefore, stands lowest in importance in considering the needs of Vine requirements; but where a complete manure was applied to the Vines, a marked difference discovered itself, as shown in fig. 171, the yield per acre in this case being 4 tons 15 cwt.

INFLUENCE OF POTASH ON VEGETABLE PHYSIOLOGY.

According to the analysis of the Grape Vine, it is found that the following quantities of chemical ingredients are required by one ton weight of fresh fruit, one ton of leaves, and one ton of stems.

Selected Constituents in One Ton each of Fresh Grapes, Vine-leaves, and Vine-stems.

	In the Fruit.	In the Leaves.	In the Stems.
	lbs.	lbs.	lbs.
Dry substances, ...	363	829	981
Mineral matter (ash), ...	17	93	40
Nitrogen, ...	2	11	4½
Potash, ...	3½	6	4
Phosphoric Acid, ...	0½	1	1½
Sugar, ...	205	40	9

The data thus given show that the stems and leaves of the Vine require the most dry substance, carbon and mineral matters, to build their fabric. Further, these organs contain the most nitrogen, showing that the fruit has utilized



Fig. 171.—Vines grown with Manure containing all necessary Plant-food, including Potash.

its nitrogen and carbon for the production of the carbohydrate, sugar. Dr. A. B. Griffiths says: "It is advisable during the ripening of the fruit that a large number of leaf-bearing shoots should be sacrificed. These leaves require a large quantity of sugar for their development, and for the support of their respiration, and thus rob the fruit of that constituent."

A good special manure recommended for Vines contains 7 parts by weight of superphosphate, 6 parts of kainit, 2 parts of sulphate of magnesia (Epsom salts), and 3 parts of nitrate of soda.

This manure should be applied in doses of half a pound to each Vine.

It has long been known that potash plays a very important part in vegetable physiology, in that it serves as a means of enabling starch to move from one part of the plant to another; for instance, from the stem and leaves into the tuber, as in the case of Potatoes. Moreover, those juices of plants which are noticeably sour, such as Lemon-juice, the sap of Rhubarb stalks, and the juice of sour Apples, Gooseberries, Grapes, and the like, commonly contain an acid salt of potash which changes to sugar as the fruit becomes ripe. It was thought by some authorities that when Grapes ripen the proportion of potash and phosphoric acid contained in them decreased, and that this was in the ratio in which the sugar increased.

Nitrate of Potash, commonly called *nitre* or *saltpetre*, is a compound of one equivalent of potash with one of nitric acid. Its composition per cent is—potash 46·54, and nitric acid 53·46. It is prepared artificially, in some parts of the Continent, from a mixture of common mould and calcareous earth with animal and vegetable remains containing nitrogen. When a heap of these matters is preserved moist in a shaded situation, and moderately exposed to the air, nitric acid is slowly generated; and this combining with the potash and other bases in the mixture, nitrate of potash and other nitrates are formed. Many composts, doubtless, contain nitrate of potash formed in this manner, which we use as a manure, though unaware of its presence.

“A great many rich and fertile soils are found to contain a small quantity of nitrate of potash, soda, or lime, which appears to produce nearly the same effect as the salts of ammonia, rendering vegetation vigorous and dark-coloured. The way in which these salts are formed will be easily understood when we remember, that whenever substances containing nitrogen decay in the neighbourhood of lime or alkaline salts, a portion of nitric acid is formed. Under these circumstances, the ammonia which would otherwise be produced is oxidized, and nitric acid and water are formed in place of ammonia; the acid combines with the alkali, and nitrate of potash or soda results. These salts are frequently found in mixtures of decomposing organic manures; they are formed in the same way in the soil itself.

Nitrate of potash is a powerful manure, conveying, as we have shown, both nitrogen and potash, and is especially adapted for fruit production, particularly Grapes, Peaches, and Nectarines. It may be applied in solution to French

Beans in pots, and to Strawberries, also to Solanums, Chrysanthemums, and flowering shrubs. Half an ounce to a gallon of water will be ample, given not more often than once a week.

Nitrate of Soda.—In the case of all the nitrates the nitrogen is actually in a condition in which the plant can take it up at once without change; consequently they are the most rapid in action of all the nitrogenous manures. Nitrate of soda should, therefore, only be applied to the soil when the plant is ready by its root-action to make full use of it, otherwise there will probably be a considerable waste, for nitrates of all kinds are easily washed out of the soil by rain or heavy artificial waterings.

For out-door crops nitrate of soda should be applied as a top-dressing, either alone or mixed with three times its weight of superphosphate, when the crop is actually established in the soil. Nitrate of soda is particularly suitable for dry seasons, owing to its great solubility, and the fact that no change need take place in it before the plant can assimilate and appropriate it as plant-food. Further, it may be mentioned, that when nitrate of soda is used, an alkali—soda—is liberated which has a decomposing action upon the minerals of the soil. It is, therefore, most important for the gardener to remember, that if the nitrates which are produced in the soil are to be taken up to the greatest advantage by the growing crop, it is particularly necessary that the land be not deficient in any of the mineral or phosphatic constituents which the plant requires.

Nitrate of soda is obtained from Chili, and is sometimes called *Chili saltpetre*. About 120,000 tons of this manure are annually imported into the United Kingdom. It can usually be obtained of 95-per-cent purity, that is, 95 per cent of actual nitrate of soda, the remaining 5 per cent consisting chiefly of common salt, water, and usually a little sand. Having this composition, nitrate of soda contains about 15 per cent of nitrogen.

Owing to this large quantity of nitrogen, and the consequent stimulating effect of the manure on a crop or plant, a better result is generally obtained by applying it in small dressings occasionally rather than in one large dressing, thus spreading the supply of nitrogen over a longer period, and so exposing the nitrate to less chance of loss by drainage.

THE EFFECT OF MANURES.

Experiments on Peach-trees.—In the State of New Jersey, Somerset County, experiments with

different manurial applications have been tried since 1887. The Peach orchard was planted with the variety known as "Crawford's Late" in April, 1884. The most recent report states that the trees on most of the plots are looking well for trees of their age. Those that have received no manure are making but feeble growth, and yield but little fruit. Nitrate of soda alone darkens the colour of the foliage, but does not, when applied alone, add to the yield of fruit. With superphosphate alone the leaves were larger and more uniform in size, but while there was a better yield of fruit, it was small. With muriate of potash the quality of the Peaches was superior. With superphosphate and nitrate of soda combined the leaves were of good colour and uniformly large, the return of fruit being satisfactory. When muriate of potash was added to the two former manures the trees were remarkably healthy, leaves and fruit of good colour, and altogether the best row of trees in the orchard. With gypsum alone the trees were feeble. The plot receiving 20 tons of dung gave the highest yield of the series, but the general appearance of the trees was not so good as were those receiving a complete supply of artificial manure.

Experiments on Tomatoes.—The following table show the results obtained with Tomatoes grown without manure, and with five different descriptions of manure:—

Table showing Manures applied, and produce of Tomatoes in pounds per acre.

	lbs.
1. Without manure, ...	453
2. Muriate of potash and bone black, ...	600
3. Muriate and nitrate of soda, 160 lbs., ...	728
4. Nitrate of soda, 160 lbs., alone, ...	642
5. Nitrate of soda, 320 lbs., alone, ...	716
6. Farmyard manure, 20 tons, ...	698

In the course of these experiments with Tomatoes it was found that the use of 80 lbs. per acre of nitrate of soda in one application, and of 160 lbs. in two applications, increased the yield without delaying the maturity of the fruit; 160 lbs. of nitrate of soda per acre in one application also increased the yield, but at the expense of maturation. The yields of fruit on different plots were increased by 35 to 60 per cent from the use of nitrate of soda. In every case there was a large profit from its use. It was also found that the use of nitrate of soda and of farmyard manure resulted in a more solid fruit with fewer seeds, than when potash or phosphates were used alone. Although it is absolutely essential that all necessary mineral ingredients shall be present in the soil, in order that the

nitrate of soda may properly perform its part in nourishing the crop, yet, these being present, a better result is obtained than when mineral manures alone are applied as fertilizers.

The directions given by Dr. A. B. Griffiths in his book on *Special Manures for Garden Crops* for the growth of the Tomato are: that the soil must be rich, as it is of the utmost importance that plants to be grown in the open should increase in strength and vitality; therefore, manure a short time before transplanting with one and a half pounds of kainit, two and a half pounds of sulphate of ammonia, half a pound of iron sulphate, and six pounds of superphosphate per square rood.

"During their growth the plants will be benefited by being watered at the roots with a solution containing one ounce of sulphate of ammonia, one ounce of iron sulphate, and one ounce of superphosphate to a gallon of water. The above-mentioned manures are also beneficial for the growth of Tomatoes under glass."

Experiments with Strawberries.—In the State of New Jersey experiments were tried with the Strawberry, the plants being set out in the spring of 1891. The soil was a sandy loam with clayey subsoil, of medium quality, and well drained.

Manures applied, and yield of Strawberries per acre.

Manures Applied.	Yield of Strawberries.
Nitrate of soda, 150 lbs., ...	1880 quarts.
Ground bones, 500 lbs., ...	
Kainit, 1000 lbs., ...	
No. 2 as above, with nitrate of soda, 200 lbs., added during growth of the crop, ...	2220 quarts.

The effect of the top-dressing of nitrate of soda was apparent almost immediately; the plants assumed a richer colour, and showed a stronger and more vigorous growth than those upon which no application was made. The plants blossomed well, and the berries set full in all cases. At the time of picking the fruit, that on the nitrated plots was larger, though no earlier, than upon the plot upon which no top-dressing had been made.

The gain in yield of Strawberries due to the top-dressing was 340 quarts per acre, or 18 per cent. It must be remembered, however, that nitrates are immediately available as plant-food, and that a top-dressing of nitrate of soda will have a tendency to increase the leaves and runners disproportionally unless the mineral elements, potash and phosphoric acid, are applied at the same time, or exist already in the soil.

If the soil we cultivate is to continue productive and yield a fair return for the labour

expended upon it, the fertility must be maintained by a gradual development of the immense store of plant-food which lies in a dormant condition within the soil, assisted from some external source in the form of manure. Judiciously used special manures, such as guano, nitrate of soda, sulphate of ammonia, potash salts, superphosphate, &c., are the agents which bring into useful activity the dormant resources of the soil; they restore the proper balance between the different constituents, and supply the excessive demand for some particular element. In addition to the special food-supply contributed by these artificial manures, they are, as a rule, more active, and give quicker returns, than farmyard or stable manure. But to the bulk of ordinary gardeners, farmyard manure is the sheet-anchor, mainly because it

is so easily applied, and most of the more important ingredients of plant-food are thus provided, although these may not always be in the best proportions.

Experiments with Potatoes.—At Rothamsted, Hertfordshire, Sir J. B. Lawes and Sir J. H. Gilbert have conducted a series of experiments upon the growth of Potatoes grown year after year upon the same land since the year 1876.

The crop is grown without manure, with farmyard manure, and with various descriptions and combinations of artificial manure, in ten plots. For the first four years the variety of Potato planted was “The Rock”, for the next eleven years “The Champion”, and for the next five years “Sutton’s Abundance”. The following table gives a summary of the produce up to the year 1895:—

Yield of Potatoes per acre, at Rothamsted.

	Good.		Small.		Diseased.		Total Tubers.		Per cent Diseased in Total.
	tons.	cwts.	tons.	cwts.	tons.	cwts.	tons.	cwts.	per cent.
Unmanured, ...	1	13½	0	5	0	1½	1	19½	3·15
Superphosphate, ...	3	5	0	5½	0	2½	3	13½	3·66
Mixed mineral manure, ...	3	7½	0	4½	0	2½	3	15½	3·45
Ammonium salts, 400 lbs., ...	1	17½	0	6½	0	1½	2	5½	4·06
Nitrate of soda, 550 lbs., ...	2	4½	0	5½	0	2½	2	12½	4·93
Ammonium salts and minerals, ...	5	18½	0	7½	0	8½	6	14½	6·26
Nitrate of soda and minerals, ...	5	17½	0	6½	0	9½	6	13½	7·00
Farmyard manure, 14 tons, ...	3	12½	0	6½	0	3½	4	2½	4·56

The general conclusions drawn from these experiments is that, although the Potato crop requires a full available supply of mineral constituents within the soil, yet, these conditions being provided, the amount of produce is largely dependent on the available supply of nitrogenous elements. In practice farmyard manure is mainly relied upon to give this substance. It is used in very large quantities per acre, and is sometimes supplemented by liberal dressings of artificial manures, both mineral and nitrogenous. The crop removes, however, a less proportion of the nitrogen of farmyard manure than any other farm crop. This is the reason why cultivators of plants which do not like crude manure, such as bulbs, prepare the ground for them by first manuring and cropping it with Potatoes, after which it is safe for the bulbs.

It was found that the most characteristic result of the increased growth of the Potato under the influence of nitrogenous manures was an increased production of the non-nitrogenous constituent—starch. It was shown, however, that for one of nitrogen supplied in manure,

the increased amount of starch obtained in the Potato was less than the increased amount of sugar obtained in the Mangel Wurzel, and much less than that yielded in the sugar Beet. It was further found that although a larger proportion of the total nitrogen of the Potato is in the albuminoid condition than in the case of root-crops, yet from 40 to 50 per cent of the total nitrogen of the tuber may exist in the soluble condition in the juice; and it is obvious that in the usual mode of cooking the Potato for the table, most of this is lost as food.

Next, the results show that Potato disease, though largely dependent on season, developed much more in tubers grown by highly nitrogenous manures, and containing a juice rich in nitrogen, than under contrary conditions. Finally, it was shown that a result of the disease is a destruction of starch, the formation of sugar, the loss of organic substance, and the growth of the fungus at the expense of the substance of the tuber by the absorption of the products of assimilation formed in the leaves and intended to be stored up in the tuber.

[J. J. W.]

CHAPTER XVI.

TOOLS, INSTRUMENTS, &c., USED IN
GARDENS.

TOOLS—CUTTING INSTRUMENTS—INSTRUMENTS USED IN
LAYING OUT GROUND LINES—MACHINES—UTENSILS
—MISCELLANEOUS ARTICLES.

Many of the tools used in gardens are so familiar to almost everyone, that a mere enumeration of them might be considered sufficient; yet the difference between a good and a bad one, both being employed for the same purpose, is of great importance. The spade is one of the most commonly used implements, and it is not perhaps too much to say, that with one of the modern improved kinds a man could do, with the same exertion, 10 per cent more work than he could with the heavy easily-clogged kinds formerly in use. But besides the advantage from more work being performed, it is always the case, that with a well-adapted tool of a superior description, the work is also better done. On this account, tools that are very common are, nevertheless, noticed, in order to point out the good properties which they ought to possess.

The care of tools, &c., is a matter of considerable importance, although it is too often neglected. Economy, not only in outlay, but also in labour, is secured by attention to the proper cleaning and storing of all tools when not in use. In large establishments, where a large number of implements of various kinds are required, a tool-shed should be provided, with arrangements for their convenient and safe storing. Brackets and hooks against walls for sieves, ropes, scythes, rakes, spades, &c., shelves, drawers, or cupboards for small tools, and boxes for labels, twine, pegs, &c., should be furnished in every orderly tool-shed, and the men should be taught to return every article to its proper place when not in use. Wet days may be turned to account by oiling, sharpening, and repairing any tools that require it. Even in small gardens a suitable place for the storage of tools ought to be found, instead of, as is too often the case, throwing them into any corner or out-of-the-way place, where they either get spoilt with rust or damp or are mysteriously missing when next required. Men work better when in good health than when in bad, and in like manner, with good clean tools more and better work is accomplished than is possible when they are either rusty or blunt or rickety.

I. TOOLS.

Spades.—Of all tools employed in gardening, the spade is the most essential. With it alone most kitchen-garden crops could be obtained, and plantations of fruit and forest trees could be formed. If a gardener were limited to the choice of only one implement, that which he would retain as the most useful would be the spade.

The English spade has long been justly considered the best in the world; and it was thought that the utmost perfection in its manufacture had been attained. Great improvements have, however, been effected of late years. Parkes' solid-socket spade (fig. 172) is perhaps the most improved form of spade up to date, wearing to a keen sharp edge. The blade being bright when new, can be kept always in that condition if properly wiped when put away.

Shovels.—These being broader and lighter than the spade, and having the edges turned up, are better adapted for moving loose soil, gravel, or sand. The handle should have an upward bend, less stooping being then required in using the tool (see fig. 173).

Picks.—There are several varieties of these, some having pointed, others cutting ends. As they are used for penetrating and loosening hard soils or gravel, or for cutting roots among sandy or stony particles, these implements require to have their ends well steeled and tempered.

The *Common Pick* has both ends pointed, and is curved, the curve nearly corresponding with the segment of a circle, of which the radius is somewhat greater than that of the curve described by the pick in making a stroke.

The *Pickaxe* is pointed at one end like the common pick; but the other end is wedge-shaped, and sharpened for use in the cutting of roots of trees, &c. The cutting edge is in the direction of the handle.

The *Mattock* (fig. 174) has one end pointed and the other flattened, the edge being transverse, or at right angles to the direction of the handle. This kind of pick is perhaps the most useful, and if only one sort were allowed, this should be preferred. A small form of it, known as the small hand-pick, is a serviceable tool when large trees are being transplanted, as it can be used in tight places for undermining, &c. The length of the head is 10 inches, and of the handle 12 inches.

Mattock or Grubbing Axe (fig. 175).—This is brought to a thin wedge shape at both ends; but one edge is in the direction of the handle,

and the other transverse to it. It is well adapted for grubbing up trees; with the flat end facing the operator, the roots may be uncovered, undermined, and sometimes more conveniently cut, than with the opposite end. When well made it is a most efficient tool for cutting and splitting, and may be used for many purposes.

The *Grubbing Mattock* (fig. 176) is somewhat like an ordinary mattock, but with shorter, stronger blades, and can be used in getting into difficult places where the ordinary mattock would be too large.

The *Pickfork* (fig. 177), or Canterbury hoe, is useful for loosening soil. By means of the fork end the surface may be broken up, and when this is too hard, or when clods have to be broken, the mattock end may be employed; it is also useful for loosening the subsoil to the proper depth, where it would otherwise form hard banks over which the water could not pass, and would consequently lodge injuriously in the softer parts.

Excellent handles of hickory wood are now sent from America for all classes of picks or mattocks. They should be made to fit into the eye perfectly.

The *Drag* (fig. 178) is a small three-pronged implement, used instead of a hoe for loosening the soil among vegetable crops in the market gardens near London. It should be more used in private establishments, especially in kitchen-gardens, and for large borders.

Rakes.—A set of iron-headed rakes of different sizes are required. The length of the head may be about 16 inches for ground that is either uncropped, or occupied with plants widely apart. The sizes may diminish by 2 inches in the length of the heads, so that the latter may be respectively 14, 12, 10, 8, 6, 4. The last will be convenient for raking between crops sown in rows, and for using between plants in flower-gardens. In the latter case, raking by drawing the teeth along the surface between the plants is frequently not so much required as a kind of chopping, so that the teeth may break down the clods. It is a great mistake to use a rake that merely passes between the plants; for when this is the case, the implement cannot be freely plied, and consequently the work can neither be so well nor so quickly performed.

When the teeth of iron rakes are driven into the head-bar through merely a square punched hole, and then clenched above, they are apt to break off level with the under side of the bar. The best are now made with the end teeth

formed out of the head and turned down, the other teeth being riveted in and very slightly curved. The socket should be long and strong and three-holed.

Rakes with cylindrical wooden heads, into which iron teeth are driven, are occasionally used for smoothing the surface of beds for seeds, and if the wood is well chosen and shaped, and the teeth nicely arranged, these are the best rakes for all kitchen-garden purposes—where rakes are required. Wooden rakes, the same as the common hay-rake, are required for raking off grass and leaves. Others, of a similar description, but made with greater care, and with teeth of tough hard wood, may be sometimes employed with advantage in light soils, instead of iron rakes. Being much larger but lighter than the latter, they can be more easily drawn over a surface of greater extent. Wooden rakes, with short close teeth, may be made to take off short grass from lawns so cleanly as sometimes to render sweeping unnecessary. The American rakes, being of light make and easily handled, are now much in favour.

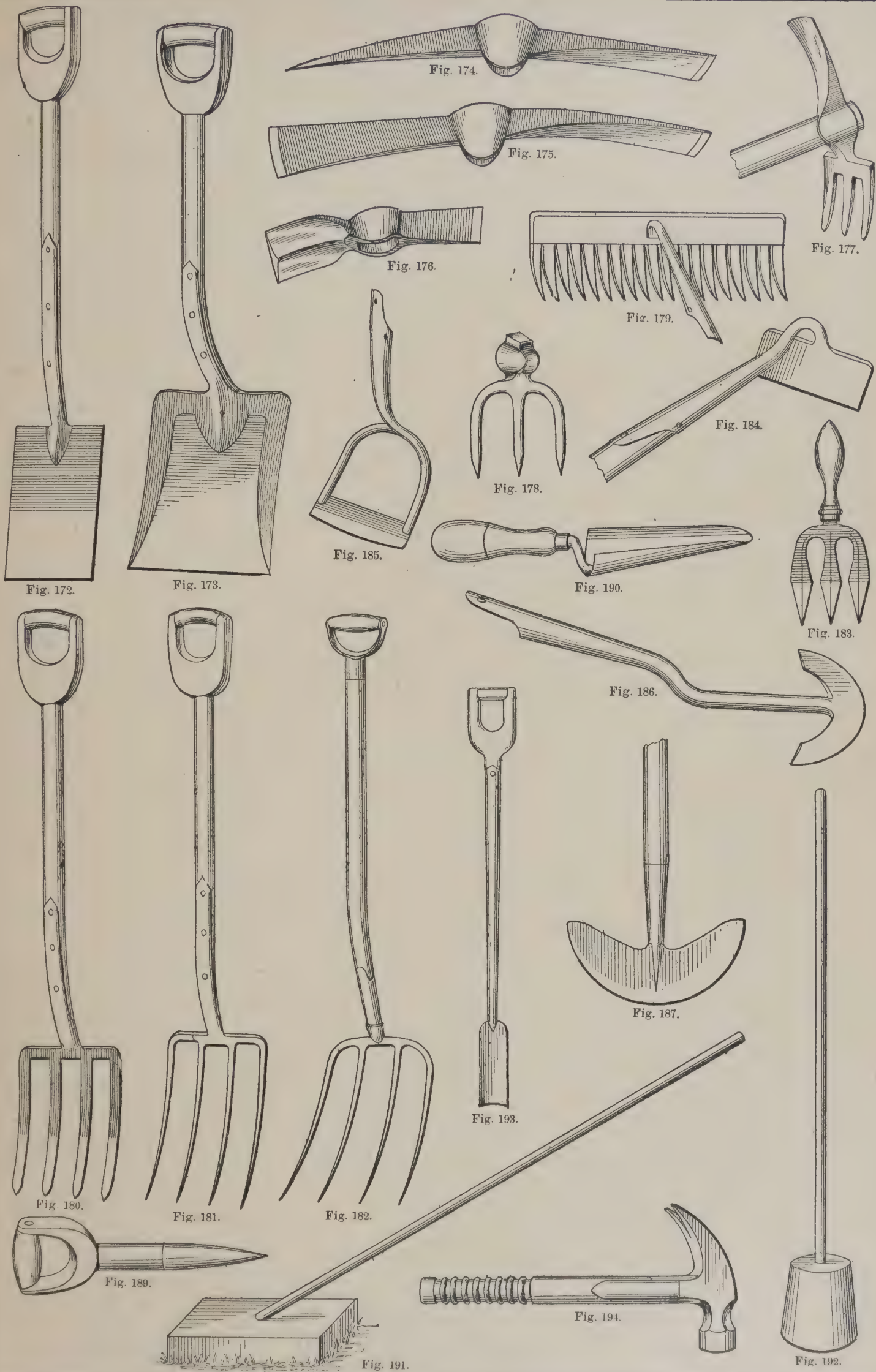
The *Daisy-rake* (fig. 179) has broad teeth, sharp on both edges; it is employed for removing the flowers of daisies and other plants from lawns.

Forks are perhaps employed for more purposes in gardens than any other tool. Parkes' steel digging forks are of very superior make, and were the first of the kind brought out. Excellent examples are now made by many other good firms.

These forks are in many cases substituted for the spade. The prongs, being made of steel, are elastic, taper to a point, and are flat, oval, round, square, or diamond-shaped, with three, four, and five prongs. The trenching fork (fig. 180) is three-pronged flat, or four-pronged square, and extra strong. Fig. 181 is a useful digging fork. The potato fork is four- or five-pronged flat, of lighter make than the digging fork. The manure fork is generally four-pronged round, very light and elastic, some with either a short handle similar to the digging fork or a long straight handle (fig. 182), the latter being very useful for long manure. The hand-fork (fig. 183) is a useful tool in many ways.

Many slight variations in shape to suit various preferences are manufactured, but those given are best for general purposes.

Hoes.—Of these there is a variety of forms and sizes adapted for use among plants requiring to be grown at greater or less distances apart; also for light and heavy soils, for drawing furrows or drills, thinning crops, stirring the soil



Gardening Tools.

between the plants, and for earthing up, &c. Some of these are draw-hoes, others thrust, and a form combining both modes of operation has been invented.

Draw-hoes should have the blade attached to the socket by a solid neck, more or less curved, as in fig. 184. The blade should be made of steel, welded on an iron neck. The length of the plate for the largest need not exceed 9 inches; hoes for Onions, &c., are required as small as

alleys, so that the ground is not trodden as it is in using the draw-hoe. For light work, and in flower-gardens, these hoes are most useful. They should be kept very sharp, and then seed weeds can be clean cut over.

The *Turf-spade* (fig. 186) may be much more advantageously used for cutting turf than the common spade. The best has a crescent-shaped blade and a bent handle, and is much superior to the heart-shaped blade, and lighter. Before using this tool, however, the turf must be cut into strips by a *Verge-cutter* (fig. 187). Wheel verge-cutters are also used for this purpose.

Turf-scraper.—In lawns where ants abound, and where their hills or where worm-casts require to be taken off, a long light scraper of wood or iron, such as that used for roads, may be usefully employed. The daisy-rake is also handy for this purpose.

The "*Planet Jr.*" (fig. 188).—Amongst combination tools, the "*Planet Jr.*" is certainly one of the most ingenious and useful. It is an American invention, where wheel-hoes, seed-drills, &c., are much more used than they are in this country. This machine can be readily adapted for performing almost every variety of gardening operations (as regards the soil) that can be required, and by its intelligent use an immense



Fig. 188.—"Planet Jr." Single-wheel Hoe.

2 inches. Draw-hoes vary in nearly every county, or even in certain districts. A very useful crane-necked hoe is in use in the midland counties, with movable steel plates 5 to 7 inches long. These plates can be used separately in the same handle and head; the act of hoeing tightens the blade in the head. Hoes of a triangular form are used for drawing drills, and sometimes for this purpose the implement is made like a hollow trowel, the convex side being towards the handle. An improvement in these consists in the convex side having an edge turned horizontally forward so as to cut without the soil filling up the groove as the implement is drawn along.

The Dutch or thrust hoes (fig. 185) are useful for cutting down weeds, and for very shallow work on an even surface; but they are not so good as the draw-hoe when the ground is stiff and lumpy. The Dutch hoe can be used to a considerable extent without going out of the

amount of labour is saved. The "*Planet Jr.*" Horse Hoe with its combinations can be used for the following purposes:—As a five-tine drill grubber; as a three-tine drill grubber; as an expanding drill harrow; as a scarifier for hoeing and cleaning away weeds from side of Turnip drills, &c., before thinning; for hoeing and grubbing and ridging-up Turnip, Potato, Bean, Cabbage, and Carrot drills; for cutting-up Thistles, pairing stubbles for catch crops, for hoeing between Strawberry rows, and for flat cultivation generally.

Dibbers.—These are generally made of the upper part of old spade handles. Being made of hard wood, they are sometimes used without being shod; but where these implements are extensively used, the whole of the cylindrical part should be sheathed in steel (see fig. 189). This maintains a more polished surface than iron, and therefore perforates with less friction, and is not so easily clogged with soil.

Dibbling, though an advantageous mode of transplanting small plants in point of expedition, is open to some objections. In it the roots are all crowded together in a narrow hole, instead of being spread out in the directions which they naturally take; when thrust in they are often reversed, or made to turn upwards; the mere act of inserting the dibber renders the soil at the sides of the hole more compact than it is elsewhere, and when the soil is heavy, or not in good working order, the trowel is much to be preferred.

The *Potato-dibber* is adapted for making a hole sufficiently large for allowing the set to drop to a proper depth. It has a cross handle at top, which can be grasped with both hands, and a projecting piece of iron or wood, serving as a tread for the foot to press the dibber into the ground. The tread might be made so that it could be shifted, and placed higher or lower, according as the hole requires to be made of greater or less depth.

Garden Trowel.—The common garden trowel, below the handle and neck, is like the curved portion of the section of a cone. But the generality of trowels made are too concave in the blade, not giving freedom sufficient to clear itself from soil. The best form should be as in fig. 190. It is now made of steel, united to a curved iron neck. It is used for many purposes, but chiefly for taking up plants and replanting them, with balls of earth adhering.

The *Turf-beetle* is a flat oblong piece of wood, used for levelling and consolidating newly laid turf. It may be formed from a thick knotted end of elm, outside slab, varying in thickness from $1\frac{1}{2}$ inch near outside edges to 3 or even 4 inches in centre, and having a handle inserted in the upper side (fig. 191). The handle should be fixed at a sufficiently acute angle with the sole of the beetle, to admit of the latter being easily brought down flat.

The *Rammer* (fig. 192) is useful for ramming the earth about posts, tree-guards, &c., and for consolidating turf and gravel. It is generally made of wood, in the form of the base part of a cone, attached to an upright stem. Rammers with cast-iron heads are also sometimes employed, and are very necessary where solid ramming is required.

Rollers.—A heavy cast-iron roller is required for broad walks, gravel areas, and for lawns. In flower-gardens, or where the walks are narrow, or their turnings intricate, a narrow roller must be employed. Iron rollers are now frequently made with the cylinder in two parts, revolving

separately on the axis, to facilitate turning without disfiguring the walk, which rollers in one piece are more apt to do when it is necessary to take a fresh direction, especially one at a right angle, or less, to that previously traversed.

Brooms.—Those used for sweeping lawns, walks, &c., are generally made of birch twigs. They are tougher and last much longer when the birch is cut early in winter, or before the sap rises. They should therefore be made, or procured from the makers, before this takes place, and should be kept in a moderately dry, airy place, where they will not be liable to get mouldy. They should be thoroughly wetted when taken out for use.

Suckering Iron (fig. 193).—This is useful for removing suckers from Gooseberries, Currants, or other shrubs. It consists of a chisel-like steeled blade, 6 inches long, $2\frac{1}{4}$ inches broad at the edge, and $1\frac{5}{8}$ inch at the shoulder, where it tapers to a straight round iron shank, the upper part of which forms a socket for the insertion of a wooden handle. The length from the edge of the tool to the top of the socket is 34 inches, and from that to the top of the wooden handle 10 inches, the whole length being 3 feet 8 inches. The edge is usually straight, and is apt to slip past the sucker; but the figure represents an improvement, the edge being concave.

The *Dock-weeder* is employed for taking up such deep tap-rooted weeds as Docks; it consists of an iron blade, with two prongs fixed in a handle, like that of a spade; a curved piece of iron on the back serves as a fulcrum; and in some forms of the implement a projecting knob answers the same purpose.

Crowbar.—The usual form of this is a round straight bar of iron, or, better still, of steel, with a pommel top; the bar is thickened a little towards the lower end, near which it is square, and then tapers to a point. It is useful for making holes for stakes; and being sometimes made flattish and wedge-shaped at the end, it is occasionally employed as a lever for loosening the soil below trees that are to be removed. A pair of good steel crowbars are useful tools for gardens of any size.

Hammer.—The principal use of a hammer in gardening is for nailing wall-trees. For this purpose the head should be rounded to serve as a fulcrum in drawing nails, and in this operation the claws should hold the nails without slipping. The head also should not be too long, otherwise, in drawing nails, it is apt to bruise adjoining branches, where these happen to be close together. A useful form is shown in fig. 194.

Mallet.—This is necessary when branches are to be cut off by the chisel, or where that instrument is employed to smooth the place where branches have been cut off by the saw. Different sizes are required for driving stakes and other purposes. Large ones ought to be secured by an iron hoop round each end; commonly called a "beetle".

Pincers and *Pliers* are requisite for drawing nails, and other purposes. Their uses are too well known to require mention. At the same time they are too often missing from the garden tool-chest. A screw-driver and file are equally necessary.

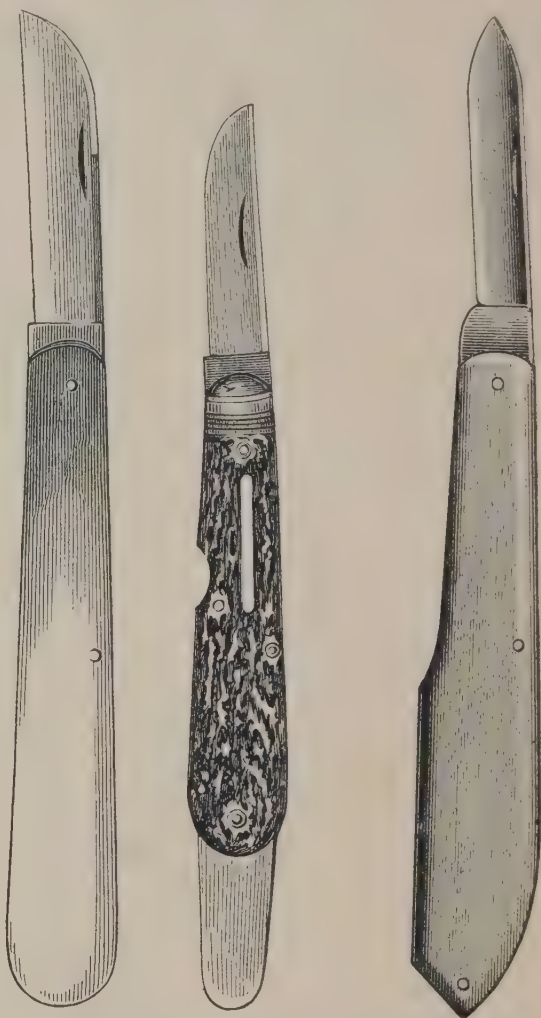
II. CUTTING INSTRUMENTS.

Knives of various kinds are required in gardens, for pruning, budding, grafting, and other purposes.

The *Pruning Knife* (fig. 195) is the best instrument that can be employed for pruning trees and shrubs, and for a variety of other purposes. There are various forms of it; the blade in some is made with a joint, so as to fold in; and in others it is fixed immovably in the handle, and kept in a paste-board sheath when not in use. Knives with folding blades possess the advantage of being more portable, and are therefore more convenient for occasional use; whilst, on the other hand, those with fixed blades are more steady in their action, and when constant pruning is carried on, are preferable. The handle should be made of buck's-horn, the rough surface of which prevents the hand from slipping. With regard to the shape of the blade, some prefer blades with straight edges; others those the edges of which are more or less curved. For removing small shoots a straight-edged blade is preferred; but where branches are to be cut off, a curved blade can be used with greater effect.

The *Budding Knife* is made in various forms. The blade is generally either straight-edged or curved backwards towards the point. The handle, which is made of ivory, is usually rounded and flattened at the end, in order that it may be used for raising up the

bark. The end of the handle is sometimes made heart-shaped, and this form admits of the bark being raised with greater facility. Instead of the



Figs. 196, 197.—Budding Knives.

Fig. 198.—Propagating Knife.

handle being thinned at the end, some knives have a common handle, and a small piece of ivory which folds in for the same purpose. Figs. 196 and 197 represent good forms of budding knives.

The *Propagating Knife* (fig. 198) is a modification of the budding knife, and is preferred for making cuttings, grafting, &c., being thin in blade and of good steel.

All knives should be kept in proper condition by frequent sharpening on a hone, with plenty of clean water, pressing the blade flat on the hone, to keep a long thin edge, which lasts longer and cuts cleaner.

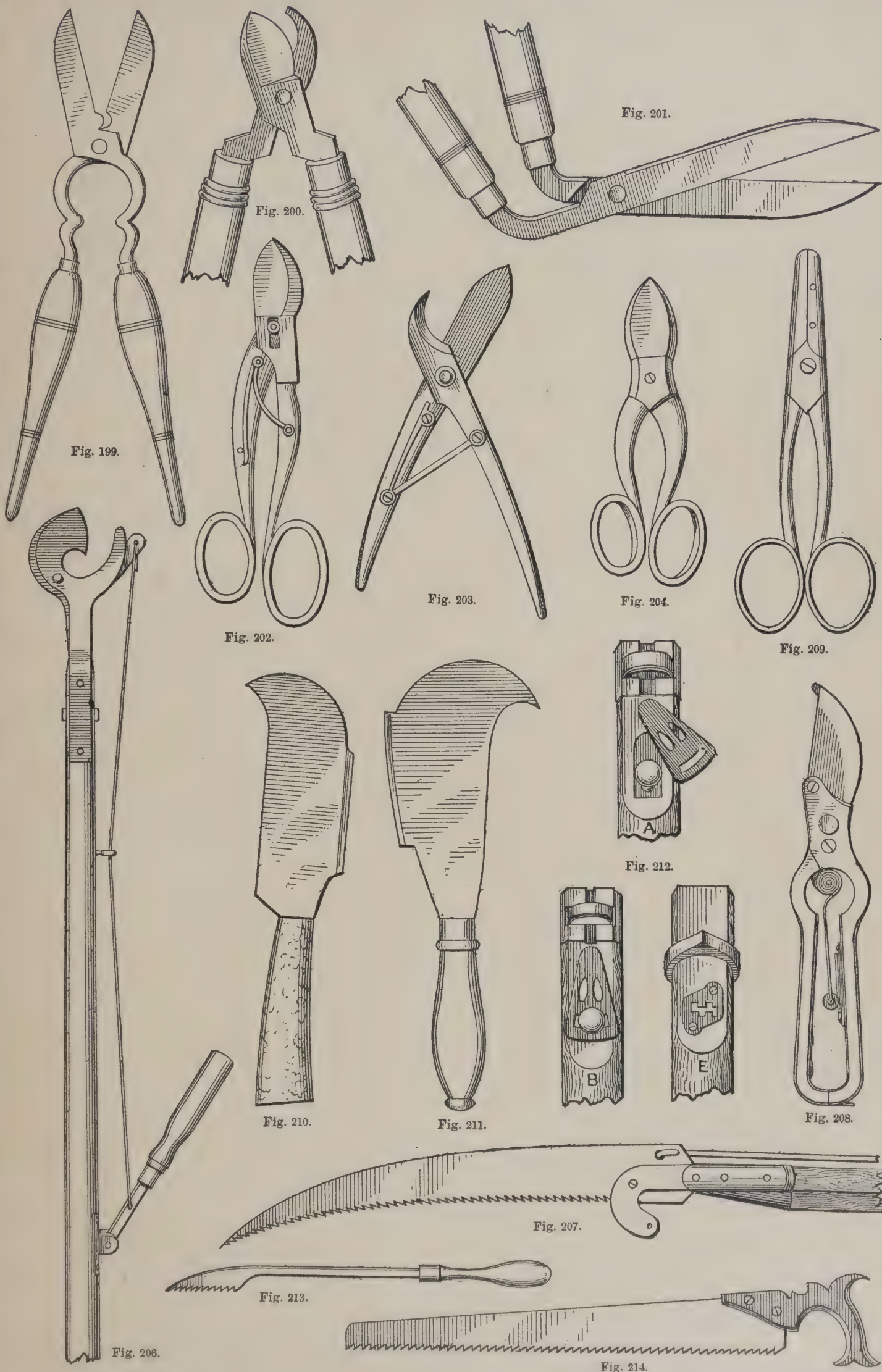
Shears are required in gardens for clipping grass edgings, hedges, and for pruning.

Hedge Shears.—A good form of these is represented in fig. 199. They are strong both in blade and shaft, the former being straight-edged, except a small portion near the pivot, which is concave and convex, so that strong branches are easily grasped and cut.

Another form of shears, known as *Lopping Shears*, is short and parrot-bill shaped in blade and long in shaft. The upper portion of it is shown in fig. 200. These are employed for



Fig. 195.
Pruning Knife.



grasping and cutting stronger branches than can be done with the ordinary hedge shears. They should have strong wooden handles about 3 feet in length, and broadly ferruled where the prongs are inserted.

Grass-edging Shears.—Some kinds of these are furnished with a small wheel to run along close by the edge of the grass; but the form represented in fig. 201 is best adapted for general use. They were formerly made with the handles at right angles to the blades, but they are now made with an angle of 110° . The axis or pin on which the blades turn should have a smoothly rounded head next the edging; that is, on the left-hand side. The other end of the axis should have a screw and nut with a washer; or there may be two thin nuts worked hard against each other, to prevent their being turned by the movement of the blades. It is necessary that the end of the screw should be on the right-hand side, otherwise it would catch against the edging.

Pruning Shears.—There are various sizes of these, according to the greater or less thickness of the shoots or small branches to be cut off. The pruning shears shown in figs. 202 and 203 are employed for the removal of the shoots of fruit-trees; and the centres being movable, they produce a draw cut like a knife, instead of a crushing cut like that of the common shears.

The shears represented in fig. 204 are useful for pruning Gooseberries, Currants, Roses, and other plants. They are very strong and effective; and being made without a slide, are not liable to get out of order.

The *Standard Tree-pruner* (fig. 205) is used for the purpose of pruning standard trees, the branches of which are situated at a considerable elevation. There are several forms of this instrument, differing slightly from that figured, but they all consist of two blades, one of which is fixed to a handle, and the other to a lever, to which a strained wire is attached. The Standard Tree-pruner is one of the best, being quicker in action and more easily adjusted. Another form is the Hook Tree-pruner, represented at fig. 206. This will cut through branches an inch or more in diameter with ease. The Aerial Pruning Saw (fig. 207), to fit the Standard Tree-pruner, is easily adjusted, and most useful for the removal of boughs too large for the "pruner" alone.

The *Sécateur* (fig. 208) is a useful form of shears of French invention. It is much more expeditious than the pruning knife, well adapted for summer pruning, and extremely useful for shortening one-year-old shoots. There are

various forms of the *sécateur*. The one most preferred in England is that here figured, which is as useful in the garden as a pruning knife.

The *Flower Gatherer* (fig. 209) is a useful form of scissors, with blades so constructed as to hold the flower after it has been severed.

Grape Scissors are used for thinning out the berries of the bunches of Grapes. They should have small tapering points; but not too sharp,



Fig. 205.—Standard Tree-pruner in use.

otherwise it is impossible to introduce them among the Grapes without pricking some of the berries not to be removed.

The Axe.—One of a convenient size is useful for many garden purposes, such as sharpening stakes; and a large one, with a handle long enough to be used with both hands, is required for felling trees.

The Hedge or Pruning Bill.—This instrument is employed for dressing the sides of hedges. It is a slightly curved blade, attached to a handle about 4 feet long. Whilst the blade is applied in a direction corresponding with that of the side of the hedge, the handle deviates so far as to permit the operator to stand clear of the hedge.

The *Bill-hook* (figs. 210 and 211) is used instead of the axe for cutting hedges and lopping branches, sharpening stakes, fagoting, and

wherever the wood to be cut is of small diameter. It varies in form in different districts or counties, the blades being more curved or longer in one district than in another.

Chisels.—These are used for various horticultural purposes, for which different kinds are adapted. Some are similar to the carpenter's chisel, and are used for cutting off branches too strong for the knife, and situated where the saw could not work; and also for smoothing the cuts made by the saw or other instrument.

Scythe.—The usual form of scythe-blade answers for lawns, provided the neck is set with the handle to take in a wider sweep, and it should also be turned up so that the under side of the blade may be nearly flat with the surface of the ground. Brades' scythe-blade still retains its character as being the very best in make and quality. The scythe-snaths (fig. 212), an improved method of attaching the blade to the shaft, are very convenient and effective, being easily adjusted, and the blade can be set in any position or angle without bending the shank or twisting the edge. The common bent handles are as good as any, if not the best. Much depends on the placing of the two projecting handles for the grasp; their distance from the heel, and from each other, should be so regulated, that the blade, when lifted up clear off the ground, will balance parallel to the surface.

In sharpening a scythe, the stone should be drawn almost flatly along the under side, so that the edge may not be turned up; the upper side should be more bevelled.

The *Asparagus Knife* (fig. 213) has a serrated blade, with a long iron shank fixed in a wooden handle. The blade should be made of hard-tempered steel. In using it, a little soil is removed with the blade from the side of the shoot, in order to discover the direction of the latter; the blade is then pushed down somewhat slanting, and the shoot is cut, or rather sawed off, near its base. In doing this, care must be taken not to injure the crown of the plant, nor other shoots that may be coming up.

Saws.—Several kinds are required for various purposes in gardens and plantations. A cross-cut saw is required for cutting down trees; and for large limbs the saws used by carpenters will answer, only the teeth may require to be wider set if the wood is soft and full of sap. Pruning saws (fig. 214), are most required for ordinary pruning; they are employed for cutting off smaller branches than the preceding, and, not being so broad, are better adapted for cutting

close to the fork of branches, or where a broader plate could not be introduced. The kind called *turning saws*, such as are used for cutting out circular spaces in boards, answer exceedingly well, and being made of the clippings taken off in cutting out other saws, they are not expensive. In some cases, pruning saws with the teeth set in their cutting edges in the direction of the handle, so as to cut by drawing, instead of by pushing forward, are of use, for these can be attached to a long pole handle, in order to reach high branches. In such cases, a saw with the teeth set in the usual way would be apt to warp or break at every thrust; but one adapted to cut by drawing is not liable to this inconvenience.

Before saws used in pruning are laid aside, they should, in the first place, be perfectly cleaned from all juice, or other adhesive substance, that may collect upon their surface. They should then be well dried and oiled. They will also work more easily, and cut more expeditiously and with less danger of breaking, if cleaned and oiled occasionally when in use.

III. INSTRUMENTS USED IN LAYING OUT GROUND LINES.

Garden Line and Reel.—A garden line should be made of good materials, otherwise it soon gives way in stretching; but however good at first, a line will soon decay if rolled tightly up when wet. It should therefore be wound on a reel, which not only permits the line to dry more speedily than when closely rolled up, but also facilitates its being readily extended and recoiled. When a line rests on the ground, its weight does not affect the straightness of the tracing; but when stretched and supported only between two points, with the intention of indicating a straight line between them, the line should combine strength with lightness, as, for instance, small whip-cord. A stout iron pin, 2 feet long, with a loop after the pattern of a skewer, is a useful fastener for a garden line.

The *Chain* is indispensable where land, walks, or roads have to be measured, and it is always desirable that there should be one in a garden, at least if it is of considerable extent. The one commonly employed, and which is used by surveyors, is called Gunter's chain. It consists of 100 links, each of which is 7.92 inches in length, consequently the whole length of the chain is 66 feet = 22 yards, or 4 poles.

One great advantage of using the chain consists in the facility with which areas calculated in links may be reduced to acres; for as there are 100,000 square links in an acre, we have only to point off five figures to the right, and the equivalent area in acres and decimals of an acre is obtained; thus, if the area be 118,960 links, by pointing off the last five figures we have 1.18960 acre. Accompanying the chain are ten small arrows, about 15 inches in length, the use of which is to mark the termination of each chain's length. A staff having been set up to show the direction of the line to be measured, a person, called the leader, takes one end of the chain, holding at the same time the ten arrows in his hand, and proceeds in a straight line towards the staff. The other end of the chain is held by the surveyor, who directs the leader till the chain is stretched in a straight line in the direction of the staff. When this is done, the leader fixes an arrow in the ground at the end of the chain, and again starts off till another chain's length is measured, the chain is then directed and stretched, and an arrow fixed in the ground as before. The surveyor picks up the first arrow, which he retains, and continues picking up the arrows as the measurement progresses: when the surveyor holds ten arrows, they are returned to the leader, and the circumstance noted. The leader then starts afresh, and the measurement is continued in the same way till the whole distance has been measured. Each change is then counted as 1000 links, every arrow the surveyor holds in his hand as 100 links, and to this are added any links that there may be over; the sum will be the length of the line in links. Thus, if there have been two changes, and the surveyor hold five arrows, and there be 13 links more, the length of the line measured will be 2513 links.

Measuring-rods.—Two thin rods, such as are used by surveyors, are useful for accurate measurements; but for common use in the open ground a 10-foot rod of clean, well-seasoned deal, about $1\frac{1}{4}$ inch square, with each foot clearly marked and numbered, may be substituted. A copper fastening should be put round each end, to prevent splitting and wearing.

It is often necessary to measure ground work and garden allotments by the pole or perch. For this purpose a measuring-rod $16\frac{1}{2}$ feet in length, divided into 100 parts, will be found exceedingly convenient; for the length in rods and parts set down as decimals has only to be multiplied by the breadth set down in a like manner, and the

area is at once obtained in rods and decimals of a rod.

Stakes.—For marking out lines for walks, boundaries, and divisions, stakes are necessary, and may be reckoned amongst the first requisites for the laying out of gardens. They are, in fact, necessary on many occasions, as when plantations, edgings, and lines have to be made out afresh. Stakes for these purposes should be made of clean, well-seasoned deal; they should be 6 feet in length, 1 inch square, quite straight, and the lower end regularly pointed. When not in use, they should be kept in a dry place, strapped together in bundles, ready to take out whenever they are wanted.

Borning-rods.—These usually consist of three straight rods of equal length, each with a cross-piece at right angles across the top. They are used for determining points that shall be either in a horizontal or uniformly inclined plane. For example, supposing the edging of a walk is required to run straight between two fixed points; then, if we place a borning-rod on each of these points, and another anywhere between, by looking over the top of one at either end, we may direct the person holding the intermediate rod to raise or lower it, as the case may be, till it is seen to be in a line with that at the farther end. For ordinary purposes, the above construction of rods will answer tolerably well; but in using them an imperfection is experienced, which may, however, be easily remedied. In looking over their tops, a fringing of the rays of light on the edges prevents the latter from being exactly seen. The following construction is therefore recommended.

Instead of the three cross-pieces being of the same width and height, one of them should be about an inch broader and higher than the others. If two have their upper edges, say 4 feet from the bottom of the rod, the upper edge of the other may be 4 feet 1 inch; but a line should be drawn exactly at 4 feet. A very small hole should be pierced through the cross-piece to form a sight; the sides of the hole should be smooth and blackened, as should likewise be the cross-piece, but not varnished. The hole should not be wider than would admit a small pin. On looking through it, the top of the intermediate rod can be easily and much more correctly placed in line with the top of the farther rod than by looking over the tops of the three.

Another set of borning-rods, shown in fig. 215, will be found handy and accurate. The sighting hole is in the plain upright rod, where a

triangular or diamond-shaped piece of zinc is neatly let in; the end T-rod has the cross-piece shaped in a rounded form and painted white.

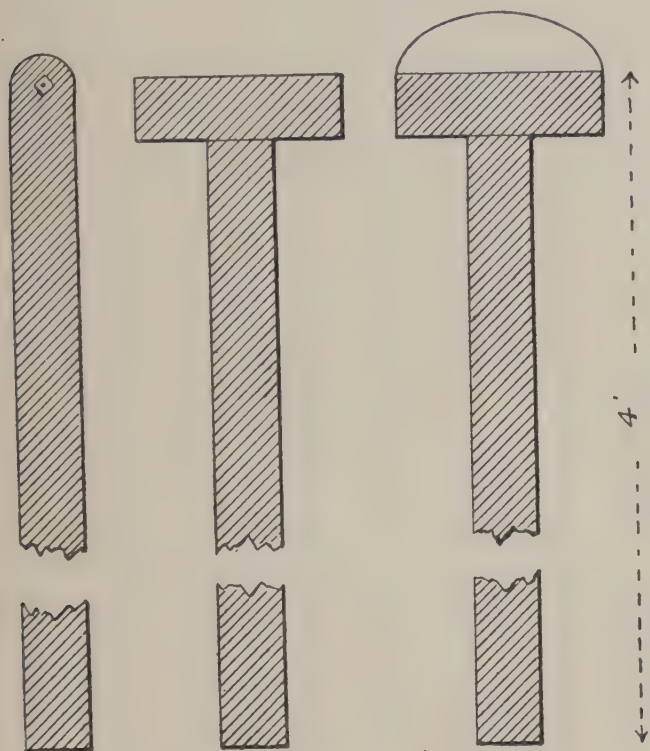


Fig. 215.—Borning-rods.

Ground Compasses.—These are useful in making geometrical flower-gardens or striking beds on lawns. They are constructed on the same principle as the common compasses, with the segment gauge used by mechanics. The legs are made of hard wood, 5 or 6 feet in length, and shod with iron. Instead of a segment, a straight plate of sheet-iron, about $1\frac{1}{2}$ inch broad, may be used, with a space cut out along the middle, through which the end of a fixed screw on each leg may pass; then, by means of two thumb-screws, the legs can be secured at any required distance apart. In many cases where the above may be employed to describe circles, or circular parts, a sort of beam compasses may be substituted. Such may be formed of a piece of inch-thick deal board, $2\frac{1}{2}$ inches wide and 10 feet in length, with a slit along the middle to within about 6 inches of each end, to admit of a screw $\frac{1}{2}$ inch in diameter passing through and along. There should be two screws, their lower ends being pointed. The length of each screw may be 18 inches, and each should be furnished with two nuts and two washers. Supposing it may be required to have the beam raised about 6 inches above the points, in order to clear any inequalities of surface which it may have to pass over, screw up the nuts, so that the under side of the beam may rest upon them at the above height; then screw down the nuts on the upper side of the beam, but only one of them tightly, until the other screw is moved along the slit, so

that the points may be at the required distance apart; and when this is ascertained to be the case, let the other nut be likewise screwed down, in order that a line may be traced without the points being moved from the true distance in the course of the operation. As this instrument can be adjusted so that the points may be securely fixed at any width, within certain limits, and as the beam can be raised more or less, it may be used as a gauge for the breadth of walks, or other distances between two points.

The *Plummet* may be very usefully employed in placing objects correctly upright, such as posts, stakes, and trees. The plummet should be formed with a conical point, and this point should be exactly in the line of suspension, so that when the cord suspending the plummet is held in line with a row of stakes, for instance, the point will touch or indicate the spot where another stake should be driven.

Levels.—Wherever walks, roads, or drains are to be made, or indeed whenever grounds are to be laid out, a level is indispensable. Though the surface of the ground may, to all appearance, be quite level, yet it will often be found, when the level is used, to slope considerably. Where walks run near the bases of walls, or other buildings where there are long horizontal lines, nothing can look more unsightly than an uneven surface; for all its irregularities are made more apparent by the horizontal lines of the building.

There are many different kinds of levels. The common level (fig. 216), used by bricklayers and

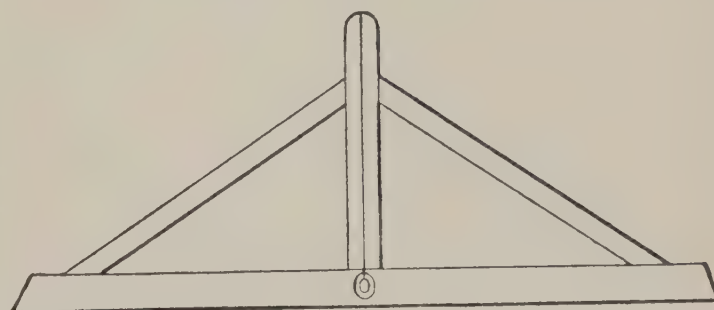


Fig. 216.—Level.

carpenters, is well known; it merely consists of a straight bar of wood, with another bar placed at right angles to it, and from the centre of which is suspended a plumb-bob and line. The level seen in fig. 217 is used not only for forming a horizontal surface, but also for ascertaining whether an object is truly perpendicular or not. The *artillery foot-level* (fig. 218) has a line and plummet, and a scale of 90° between the two legs. When the plummet hangs in the middle of the scale, the feet rest on a level surface, otherwise one foot must be raised, and the degree of acclivity or of descent will be shown

on the scale by the line. The above kinds of level are very useful in the garden whenever any building operations are carried on, or in laying down paving, &c.; and even for ground work, when it is of small extent, or when it is to be left to the execution of those who cannot use the spirit-level.

But wherever long horizontal, or uniformly sloping lines, are to be formed, the spirit-level is by far the best and most expeditious. The usual form of mounting in brass, or in wood faced with brass, except over the tube, is well known. They are now frequently bedded in a straight-edge board, several feet in length, and are thus used by builders and others.

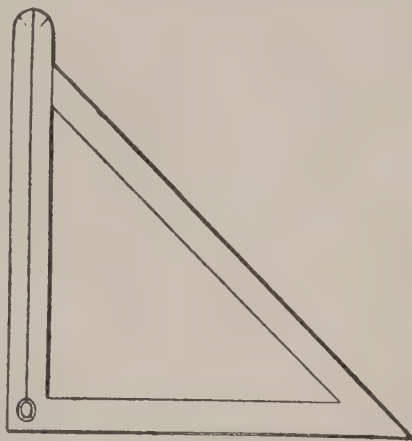


Fig. 217.—Level.

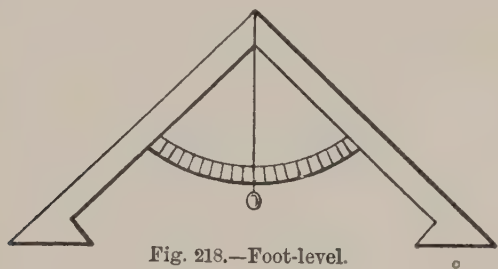


Fig. 218.—Foot-level.

A straight-edge board, say 5 or 6 feet in length, 4 inches broad, and $1\frac{1}{4}$ inch thick, with a spirit-tube bedded in the upper edge, will be found very useful in gardens. For example, in making walks, and having one edging level, the other

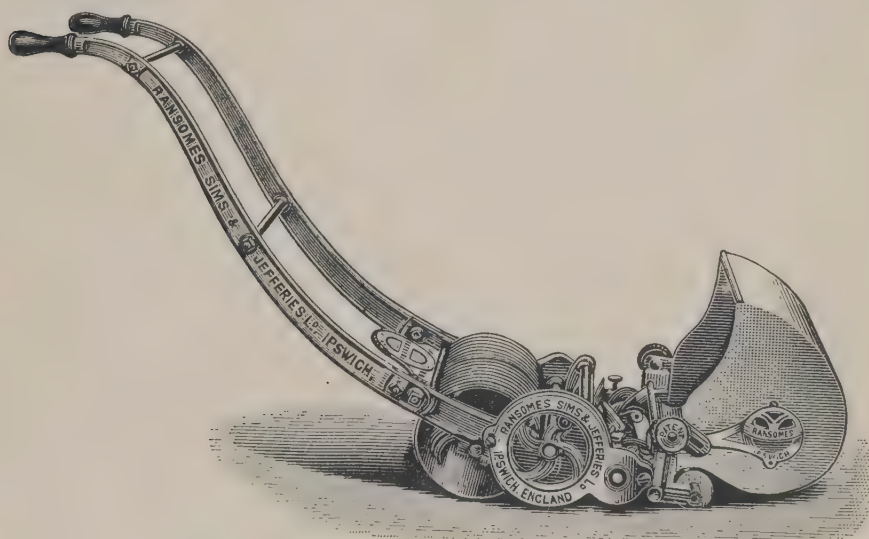


Fig. 219.—Automaton Mower.

side can be readily brought to a corresponding height by levelling across.

For taking extensive and important levels, to a high degree of accuracy, an experienced surveyor should be employed, and he provides the

necessary instruments, such as the theodolite, &c.

Lawn-mowers.—Since the invention of the lawn-mower for the cutting of short grass, not



Fig. 220.—Anglo-Paris Mower.

only is the lawn kept in better condition, but it can be kept at much less cost than when the scythe alone was used. Mowing-machines are made of various sizes, ranging from the toy-like article cutting a few inches to that of the horse or motor machine cutting 30 inches. The most useful size is that cutting 12 or 14 inches, to be directed by a man and a boy. Considerable variety exists amongst lawn-mowers, the majority of those used in this country being what are termed gear or wheel-driven. One of the best examples of these is Ransome's Automaton (fig. 219). Shanks's New Patent is also greatly recommended, especially the horse-power. Green's lawn-mower, again,

is worked by a flat link chain instead of the cog-wheel, and performs the cutting almost without noise, which is a recommendation. Green's "Silens Messor" and Ransome's "Chain Automaton" are good examples of the chain-action mowers. Another useful lawn-mower is the Archimedian, of American invention, and so named on account of its similarity to the Archimedian screw. Having only two cutting blades placed wide apart, which revolve with great rapidity, it is adapted for cutting long grass. Good examples of this principle are William's Archimedian Excelsior, Anglo-Paris

(fig. 220). These, it will be seen, have a central handle, and the cutting cylinder, which has fewer blades, is fixed to revolve more rapidly. Owing to the less resistance from the fewer blades, these machines are remarkably easy to work, and as

they are equally perfect in their cutting action, they are strongly to be recommended to ama-

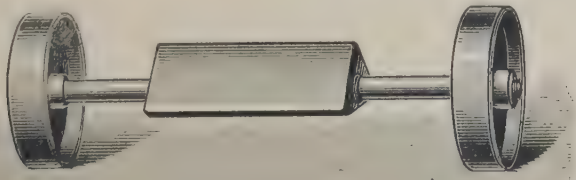


Fig. 221.—Lawn-mower Carriage.

teurs who find pleasure in taking a share in the work of their gardens. One of the special

features of this machine is its extreme simplicity, as it is composed of the smallest number of pieces of any machine extant. In the figure the grass-box is shown detached, but it fits on to the front of the machine in the same way as that represented at fig. 219. There are numerous other forms of lawn-mowers in the market, most of which differ only from those here described in some non-essential detail. In this respect they may be compared with the bicycle. Some of them may have, as claimed by their makers, superior points, such as the number of cutters, the presence or absence of grass-boxes, covered gearing, front rollers, movable plates, &c.

The Lawn-mower Carriage (fig. 221) has been designed for conveying lawn-mowers from place to place, so as to avoid running them over gravel or rough ground, which is apt to damage the knives and gearing. The machine has only to be raised at the handles and the carriage pushed under it so that the part

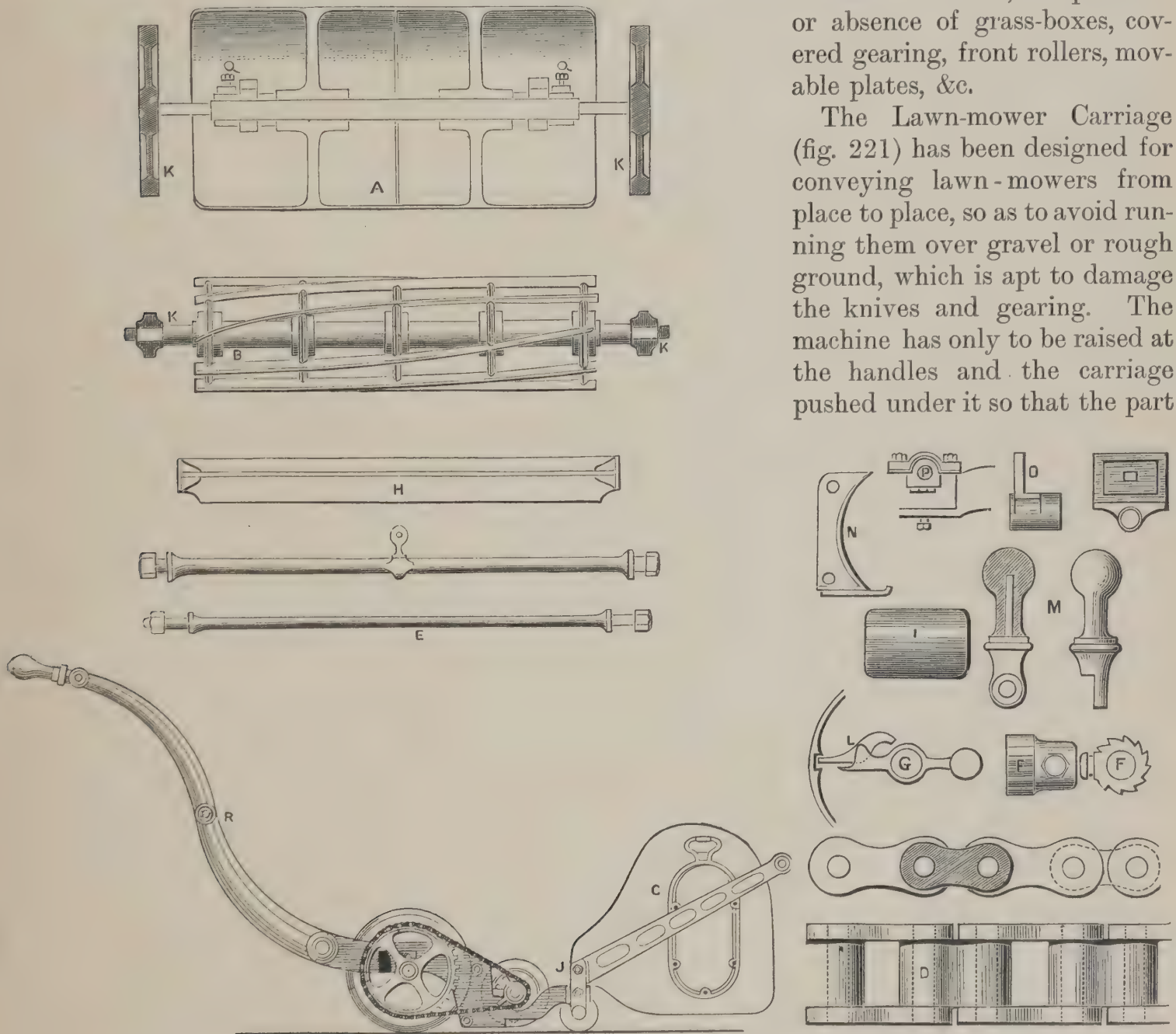


Fig. 222.—Parts of Lawn Mower (Green's "Silens Messor").

A, Drums. B, Cylinder. C, Grass-box. D, Chain. E, Cross-stay. F, Catch-wheel. G, Catch motion. H, Drum scraper. I, Front roller of wood. J, Front roller fixed. K, Chain-wheel and pinion. L, Catch lever. M, Handles. N, Sole-plate and bottom blade. O, Drum fixings and screws. P, Cylinder bush with adjusting screws, &c. Q, Catch-for-catch motion within drums. R, Machine sides, right and left.

of the machine in front of the rollers may rest on the wood cushion of the carriage. The machine is then lowered on to the carriage, and may be wheeled about with the greatest ease.

The illustrations (fig. 222) explain the construction and fittings of a popular lawn-mower (Green's "Silens Messor").

Hose-pipes (fig. 223).—A good supply of hose-pipes should form part of the equipment of every garden, the health of many plants being jeopardized in dry weather when watering is difficult. Water should be laid on wherever it is likely to be required, and either hydrants or stand-cocks placed at convenient intervals in all

parts of the garden where there are plants that would require to be frequently watered in the absence of rain. It is best to get good stout hose of as large a bore as can conveniently be used. The wire-armoured hose is economical where it has to be dragged about much. When not in use it should be kept on a reel in a dry shed. An excellent labour-saving invention is

one known as the "Irrigator". It consists of several lengths of iron pipes, an inch or so in diameter, connected by short pieces of hose, and supported on pairs of wheels. The pipes are perforated with small holes. It is connected with the water-pipes by means of a length of hose, and the spray of water can be so regulated that a constant steady shower falls on the

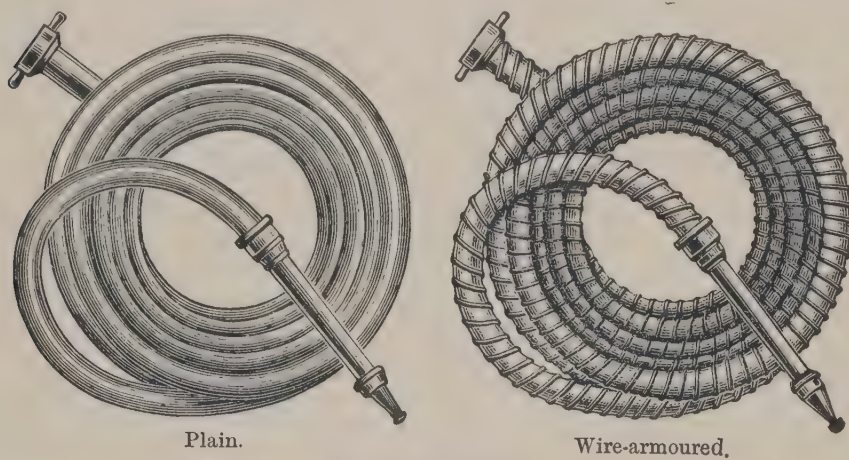


Fig. 223.—Hose-pipes.

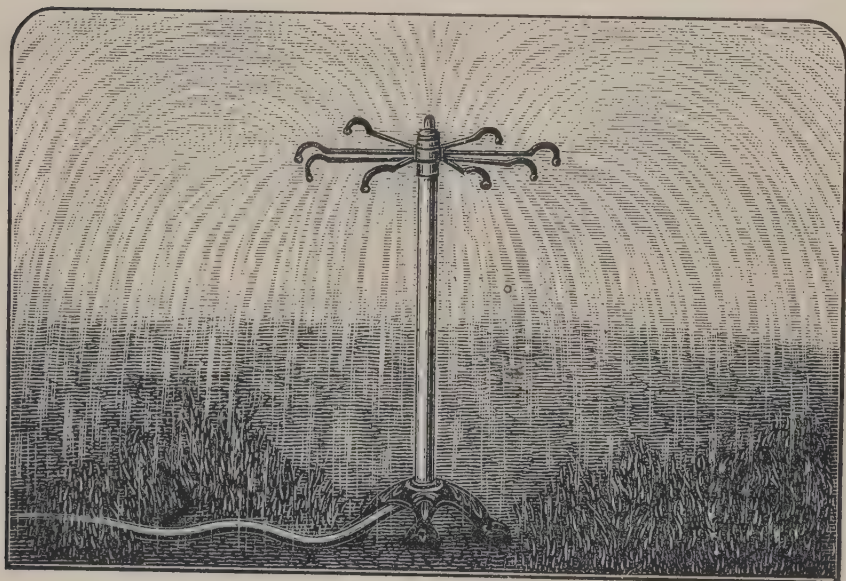


Fig. 224.—Lawn Sprinkler.

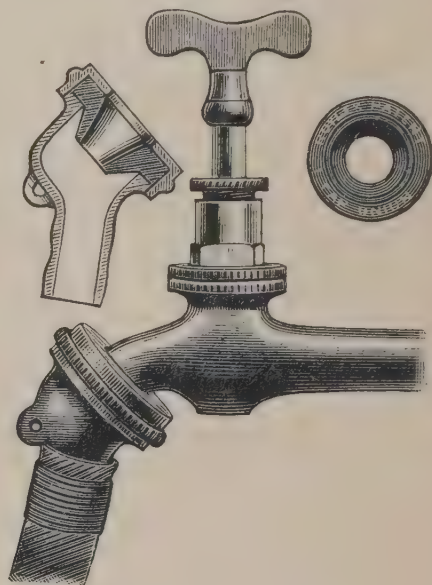


Fig. 226.—Royle's Tap-union.



Fig. 225.—Ball-nozzle Sprinkler.

plants, &c. It can be left until the ground has had a thorough soaking, and then moved to another place. For watering large trees or beds which have become very dry this contrivance is specially valuable. It is in constant use during the summer at Kew. The Lawn-Sprinkler (fig. 224) is useful for watering flower-beds, &c., or even as a substitute for a fountain. The Ball-nozzle Sprinkler (fig. 225) is an equally useful appliance, throwing out a spray similar to that shown in fig. 224. Royle's Tap-union (fig. 226) is a simple and excellent rubber contrivance for slipping on to taps instead of the cumbrous and often leaky screw-nozzle.

Watering Engines.—Of these there are many kinds used in gardens, some being hand-engines, and others barrow-engines. They are now made to act on the principle of the force-pump, that

is, a cylinder or pump barrel is fitted with a piston; on this being drawn up a vacuum is produced, and the water in which the lower end of the cylinder is immersed, is pressed upon by the atmosphere and driven up into the cylinder, which is thus filled with water as far as the piston is raised. A valve at the bottom of the pump barrel prevents the water from returning into the tank. A communication with a side vessel is closed by a valve at its base, and the side vessel is closed air-tight round a tube reaching nearly to its bottom. On the piston being pressed down the water forces open the valve of the adjoining vessel, in which it consequently rises by every downward stroke of the piston, and covers the lower end of the tube. When this takes place, the free egress of the air in the top of the vessel is cut off, and it is compressed

as the water is forced in from the barrel through the valve below. But the water itself is equally pressed upon by the elasticity of the compressed air, which acts like a spring till it regains its natural space; and so long as this is not attained, the water will be constantly forced up into the tube, and be discharged in a continuous stream,

or streams, according as it is allowed to escape at top through a single pipe, or through the perforations of a rose. We have thought it necessary to endeavour to explain the principle of these pneumatic engines, and it may be well to give some idea of the force which may be exerted by means of the above arrangement;

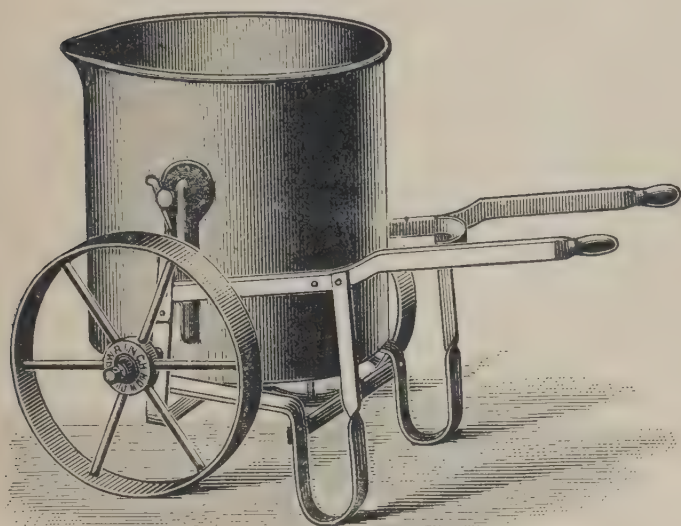


Fig. 229.—Swing Water-barrow.



Fig. 227.
Green's Garden Engine.

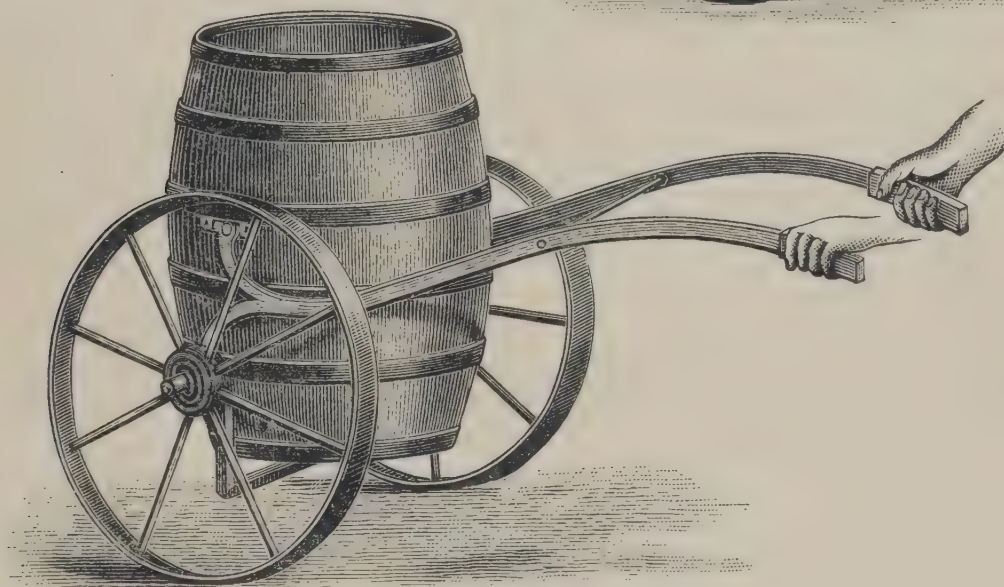


Fig. 228.—36-Gallon Water-barrow.

for, in ignorance of this, certain parts are often torn to pieces. By means of the leverage afforded by the handle, a man pressing upon the latter with a weight equal to 10 lbs., may communicate to the piston a pressure of 100 lbs. on the inch, and this pressure will be communicated to every square inch of the interior of the pipe, should any obstruction prevent the discharge of the water. On a portion of a pipe 1 inch in diameter and 12 inches in length, the pressure would therefore amount to 3770 lbs. This shows that the machinist should make the tubes very strong, and that the person who uses the engine should not urge the piston too

much, when he has cause to suspect that some obstruction has taken place. One of the handiest of these engines is Green's Garden Engine (fig. 227).

Improved Water-barrow (fig. 228).—This is an excellent form of water-barrow, by means of which several barrels can be in use at once, as each barrel can be set down. The stout iron pivot securely fixed to the sides of the barrel, drops into a slot formed on the ends of the iron frame.

Another useful form of water-barrow (fig. 229) is made with wrought-iron frame and galvanized steel cistern. It is largely used by Orchid-growers for dipping baskets, &c.

Sprayers.—The importance of a knowledge of how to overcome or prevent the wholesale destruction of garden crops by the attacks of

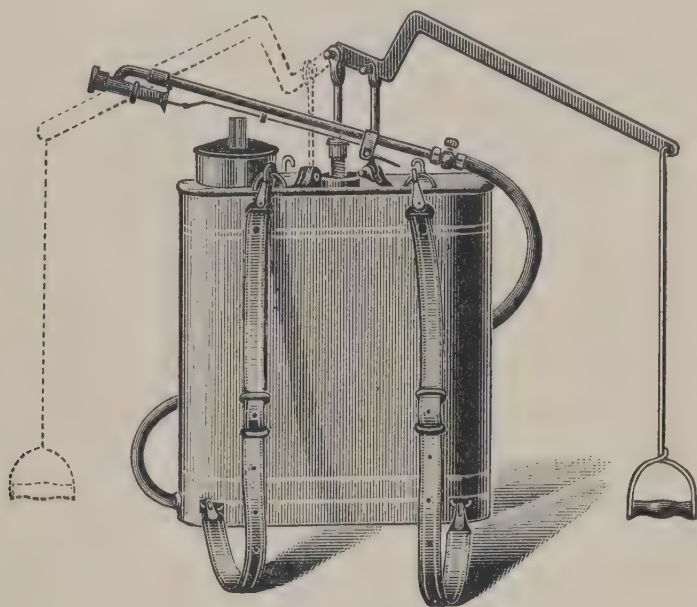


Fig. 230.—Knapsack Pump.

insect and fungoid diseases has only recently been recognized in English horticulture. Special appliances are necessary to enable one to distribute an insecticide over the whole of the trees in an orchard or a field of Potatoes, for instance, and these are now to be had, chiefly from French and American makers, who have invented various kinds of pumps, sprayers, &c., for use in orchards and other parts of the garden. In some of them there is a contrivance for thoroughly mixing kerosene with water as it leaves the engine. The pests and diseases for which these sprayers are used, and the remedies to be applied by them, are dealt with elsewhere. The two kinds of sprayer illustrated here are the "Knapsack Pump" (fig. 230), made of brass and copper, which may be carried on the back and worked easily with one hand, whilst the other directs the spray delivered through a piece of hose a yard long. The other is the "Brass Spray Pump" (fig. 231), fitted into a galvanized-iron bucket, which may be easily carried about. In the United States large spray-pumps are used, which are driven by gasoline engines carried on four-wheeled horse-wagons. They are designed to distribute solutions of copper-sulphate, Bordeaux mixture, Paris-green, kerosene, am-

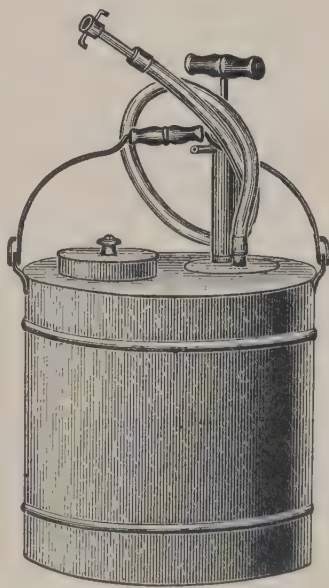


Fig. 231.—Spray Pump.

moniacal copper carbonate, sulphate of iron and sulphuric acid, &c.

An excellent "Hand Vaporizer" (fig. 232) is supplied by F. Muratori, 26 Rue de la Folie-Méricourt, Paris, price 25 francs. It holds 2 quarts of liquid, and is easily manipulated, distributing a vapour or spray in any direction, and as it can be held in one hand, the other is free to move leaves, &c. It will be found useful both for applying insecticides and for dewing

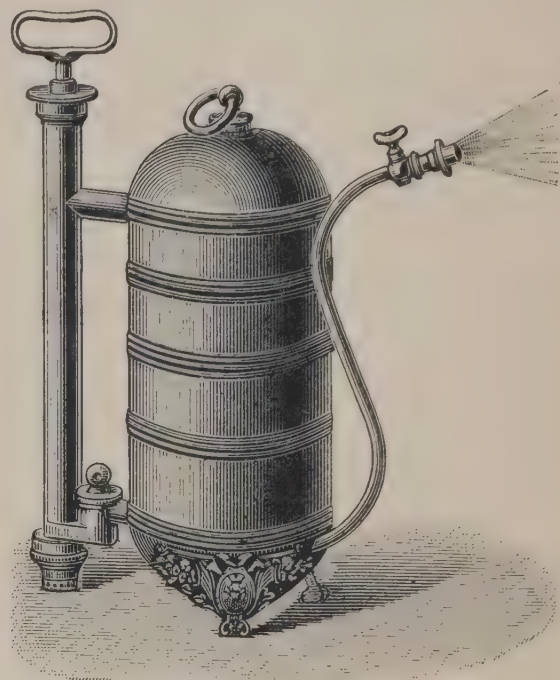


Fig. 232.—Hand Vaporizer.

Orchids, &c. Full directions for its use are supplied with it.

IV. MACHINES.

Barrows are amongst the first requisites in every garden. The common garden barrow is too well known to need description. A barrow of a different shape (fig. 233) is used in the market-gardens about London. With the exception of the wheels, it is such as a handy

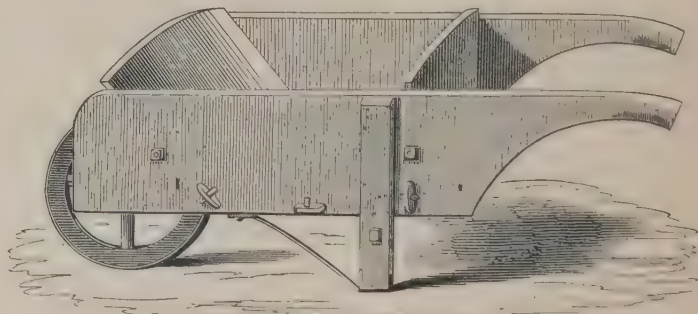


Fig. 233.—Box-barrow.

man can make in wet weather. The wrought-iron barrow finds favour in some gardens. It is light, moves easily, and is less likely to break than a wooden one. One of the many forms of iron barrows is shown at fig. 234.

The *Navy's barrow* is perhaps the best

adapted for excavating, or other work where planks are required. From its wide shallow form, it can be more easily loaded and emptied

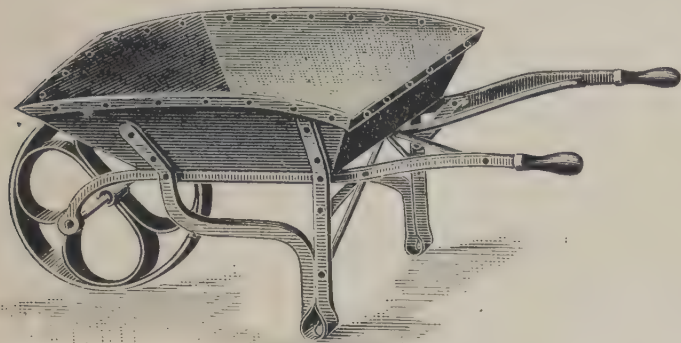


Fig. 234.—Wrought-iron Barrow.

than barrows with deeper and more upright sides. The wheel is narrow, and made entirely of cast-iron, so that little soil adheres to it. In wet weather, and with clayey soil, wheeling on planks with a broad wheel would be almost impracticable.

The coster's barrow, or a slightly modified form of it, is now largely used in gardens, especially in nurseries where large numbers of plants have to be moved quickly from place to place.

Hand-barrows.—These are easily made, the simplest being a shallow tray-like box 4 feet by 2 feet 3 inches, with the sides extending



Fig. 235.—Fruit Hand-barrow.

about a foot each way, and shaped to serve as handles. By adding short legs to this, it becomes what is called a fruit hand-barrow (fig. 235).

The *Truck Basket* (fig. 236) is the handiest

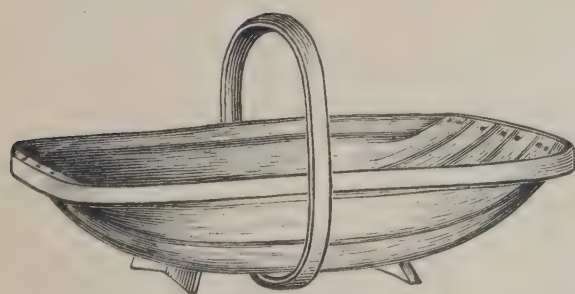


Fig. 236.—Truck Basket.

form of carrying conveyance for small quantities of soil, &c., for which a barrow would be too large. It is made of thin strips of tough wood nailed on a stout frame, several sizes being supplied. It is quite as useful an article in the garden as the wheel-barrow.

Fumigators.—These are contrivances for applying tobacco-smoke and other fumes for the destruction of insects which infest plants. The principle is to apply it in such a way that whilst it is strong enough and remains about the plant long enough to destroy the insects, it does not injure the plant. The simplest method, when tobacco is to be used, is to make a hole in the side of a flower-pot, or, better still, an old zinc pail, near the bottom, so that the nozzle of a pair of bellows can be introduced. A little live coal is put into the bottom of the pot, then the tobacco-paper, and by gently blowing, slow combustion is produced.



Fig. 237.—Richards' XL-All Vaporizing Fumigator.

An iron pot with a gridiron bottom, and a handle at the side like a sauce-pan, is a convenient utensil for this work. For very large houses, such as the Palm-house at Kew, a small portable forge, such as smiths use, is an excellent fumigator, as it can be made to pour out great volumes of smoke with great rapidity.

One of the most efficacious of all fumigators for small houses is Richards' XL-All Vaporizing Fumigator (fig. 237). It is a short cylinder, with a shallow saucer on top containing a small quantity of a liquid compound simply evaporated by the agency of a spirit-lamp. It is extremely easy of application, certain in its effects upon insects, and quite harmless (with few exceptions) to the most tender foliage.

Sulphurator.—Since the attacks of mildew on the vine and other plants have become so prevalent, and as flowers of sulphur is the best-known remedy, sulphurators have become very necessary. Accordingly, various kinds have been invented, some working with a wheel, on the principle of a fan, others like the bellows. Fig. 238 represents one which answers exceed-

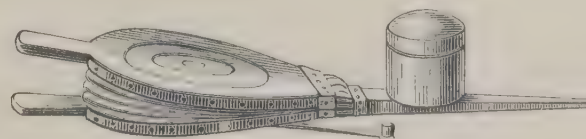


Fig. 238.—Sulphurator.

ingly well. The boards forming the sides of the bellows are 7 inches in diameter, forming two-thirds of a circle round the flap opening,

then tapering to the place where the nozzle is fixed on the wood. The upper board is cut across, the leather covering over the cut forming the hinge for allowing the board to move up and down. On the upper side of the tube is a circular tin box, 3 inches in diameter and $2\frac{1}{2}$ inches deep, for holding sulphur, which, on being introduced, and the lid fitted on, passes through holes in the bottom of the box and upper side of the tube, from the interior of which it is expelled by the action of the bellows. On the under side will be observed a thin spring strap, bearing at its farther extremity a piece of iron which strikes against the tin tube as the bellows is worked, and shakes the sulphur into the tube when it would otherwise not pass through the holes. The boards are made of thin hard wood about $\frac{4}{10}$ -inch thick. The leather is also very thin and exceedingly pliable, and to this must be ascribed the superiority in extent of blast which this small apparatus possesses over those of larger dimensions but with thicker leather. The above is a cheap, convenient, and easily worked apparatus. The Powder Distributor, a rubber bag with a perforated nozzle (fig. 239), is a very useful distributor for sulphur or tobacco powder, to use with one hand, manipulating the foliage or plant with the other.



Fig. 239.
Powder Distributor.

Syringes are indispensable where there are glass structures for plants and forcing; and in small gardens they may be substituted to some extent for the garden engine, as regards fruit-trees. There are many kinds, that shown in fig. 240 being a great improvement on the old

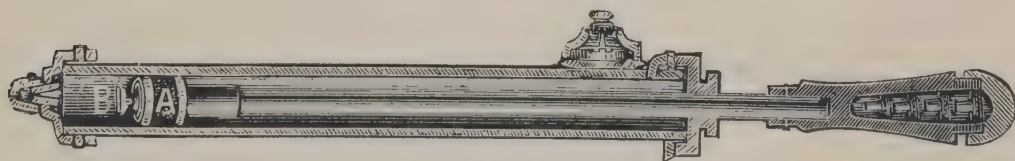


Fig. 240.

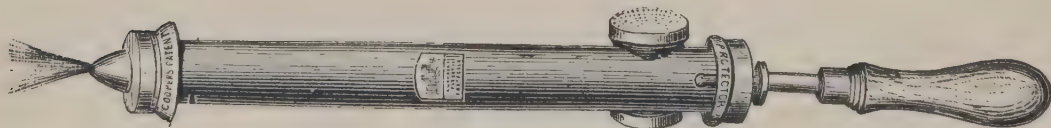


Fig. 241.

form; for, however fine may be the rose used, the water can be readily drawn up. This is owing to the water being chiefly admitted through a nozzle, in the neck of which a ball-valve is caged.

When the piston is drawn up, the ball is raised sufficiently to admit plenty of water; and when the piston is pressed down, the ball is driven

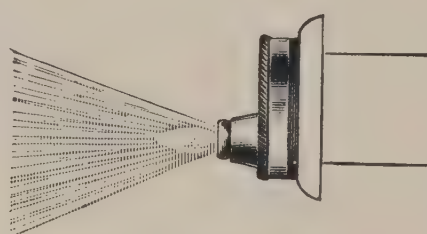
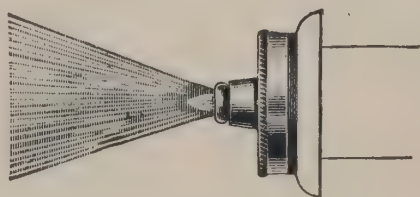
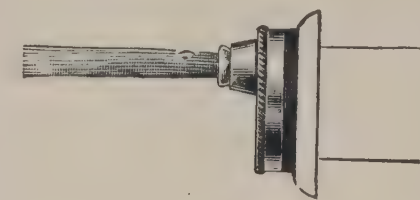


Fig. 242.—Triplex Rose.

forward and closes the nozzle, so that the water can only pass out through the perforations of the rose. The syringe is furnished with two roses of different degrees of fineness, and a single tube when it is requisite to force out the water in one unbroken stream. These syringes are now fitted with a Patent Water-tight Plunger, or Piston (fig. 241). The plunger has a strong india-rubber base, with an outer case of felt (A); the rubber ensures the elasticity necessary to produce constant, sound working; the felt retains the oil, ensures smoothness, and prevents corrosion of the rubber with the metal. The plunger can be compressed or loosened as required, being controlled by a thumb-screw (B). An improved "rose", attached to what is called White's Patent Triplex Syringe, is an ingenious arrangement of ball and nozzle which emits either a fine or coarse spray, or an unbroken stream, by slightly altering the position in which the syringe is held (see fig. 242). This rose has also been adapted for use upon a hose director. In using syringes, great care should be taken not to indent their sides through rough handling, as a single indentation renders the cylinder no

longer a true one, and then the piston cannot fit accurately. In every house where a syringe is required, two curved hooks should be fixed up in a convenient position to lay it on when not in use.

V. UTENSILS.

Pots.—These are generally made of clay, a certain quantity of which is called a cast of from one to eighty pots, according to their size. The dimensions of the pots made in London and its vicinity are as follows:—

NAME.	Number to the cast.	Diameter at top.	Depth
		Inches.	Inches.
Twos, or 18-inch	2	18	14
Fours, or 15-inch	4	15	13
Sixes, or 13-inch	6	13	12
Eights, or 12-inch	8	12	11
Twelves, or 11-inch	12	11½	10
Sixteens, or 9-inch	16	9½	9
Twenty-fours, or 8-inch	24	8½	8
Thirty-twos, or 6-inch	32	6	6
Forty-eights, or 5-inch	48	4½	5
Sixties, or 3-inch	60	3	3½
Eighties, or thumbs	80	2½	2½

The dimensions of pots vary, however, considerably, according to the locality and the particular pottery in which the pots are made.

The various sizes of garden pots have one prevailing characteristic in their form, which is

that of being wider at top than at bottom. This is necessary as, if the sides were perpendicular, the ball of earth could not be turned out without breaking the pot. Sandy soil, even without roots growing in it, could not by any means be pressed out of an earthenware cylinder, unless a very short one. On the other hand, long tapering pots are not to be recommended. Generally, pots of large size are wider than they are deep; and on the contrary, the depth of small-sized pots equals or exceeds their width. Examples of the usual forms of plant pots, pans, and baskets are represented in fig. 243.

It has been a question whether glazed or unglazed pots are best for plants. The glazed pots have a clean appearance; they do not



Fig. 243.

a, Orchid pot. b, Orchid pot (loose bottom). c, Perforated Orchid pot. d, Shallow suspending pan for Orchids. e, Suspensing Orchid basket. f, Nest of pots, 1½ to 30 inches. g, Sea-kale pot. h, Rhubarb pot.

evaporate so much water as the porous earthenware; and the ball can be more easily turned out in shifting from the smooth glazed surface than from a rough one. In these respects the glazed pots have some advantages; but these are more than counterbalanced by the higher price, which in extensive cultivation would be a consideration. The glazed surface is also objectionable as affecting the growth of the plants, chiefly because the soil gets less aeration in a glazed pot than in the rougher and more porous kind.

Drainage for the roots of plants being essential, it is usually provided for by one hole in the bottom, or by several smaller ones in that part, and in the side near the base. For large plants, however, pots are now made with one hole in the bottom large enough to admit the

end of an upright post, and over this is laid a stout movable bottom without holes. When the plant is to be shifted, the pot is kept upright and placed on the top of the post, and thus the pot is pushed down, whilst the ball is not, but remains on the top of the post, with the flat circular bottom under it.

It is frequently necessary, as a protection against slugs, beetles, &c., to isolate a plant by surrounding it with water. An excellent contrivance for this purpose is Warne's Protector, represented at fig. 244. The platform is open right through, and it is set in a dish which can be filled with water.

Besides the common forms, pots are made with double sides, with raised bottoms, also with projecting bases. The double-sided pot has a small opening at top by which the space

between the two sides can be filled with water, and thus the withdrawal of moisture from the soil by evaporation from the sides of the pot is prevented. But the same object is usually effected by placing one pot within another of a

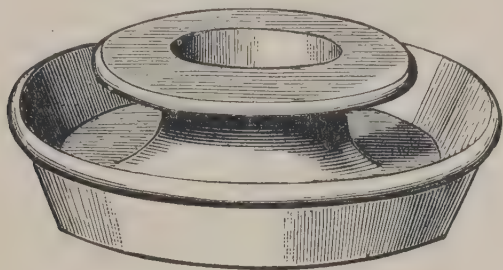


Fig. 244.—Warne's Plant and Orchid Protector.

size or two larger, and stuffing the space between them with moss.

Flower-pots vary much in quality, according to the clay of which they are made, and the amount of burning they may receive. If soft—that is, slack burned—they absorb moisture too freely, become dirty frequently, soon getting coated with moss, and are, moreover, easily broken. On the other hand, some are too hard and brittle, and also break easily.

Shallow pots and pans, the latter either square or round, of various sizes, are used in propagating. Square-oblong, about 10 inches by 7 inches, are certainly best for propagating purposes, economizing the space in the various positions where placed.

Earthenware Saucers or Flats are made of different sizes, to suit those of the pots which are placed in them. Glazed saucers for plants in rooms are sometimes made, and are preferable because they do not allow the water to pass through and cause damp on whatever they may be set.

The *Blanching Pot* (fig. 243, *g, h*) is used for blanching Sea-kale, Rhubarb, &c. It is an earthenware pot which is made in various shapes, and has a top which may be removed, so that the fitness of the vegetable for use may be ascertained without lifting the whole pot. Frequently common garden pots, with the hole in the bottom covered with a piece of slate or flat tile, are substituted for blanching pots, and answer the purpose very well.

Plant Boxes or Tubs are used for growing Orange-trees and other plants of large size. They should be made of well-seasoned pine, oak, or teak, the price varying according to the material, teak being dearest. A useful plant tub, durable and cheap, may be made from a disused beer-cask, which a brewer will sell for a few shillings. This, when cut down about one-fourth, the other end pierced, and painted

green or brown, serves very well for large plants in a conservatory. Slate is also sometimes used. Slate boxes possess the advantages of great durability, and of being easily kept clean and free from insects, to which they do not afford so many lurking-places as the wooden ones. They are, however, not as good for many plants as those made of wood. The orange-tree boxes used at Versailles are conical and made of oak; the bottoms are pierced with holes to allow the water to pass away; two of the sides are fixed, the others are movable; and each of the movable sides is kept in its place by iron bars, one end of which turns on a bolt, whilst the other lies in a hasp, and may be lifted up when the side is to be taken out. These boxes last for fifteen or twenty years, and in them are growing trees 30 feet in height with stems 39 inches in circumference, and said to be upwards of 300 years old.

M'Intosh's Plant-box (fig. 245) has a neater appearance than the preceding; and all its sides being movable, it offers greater facilities for

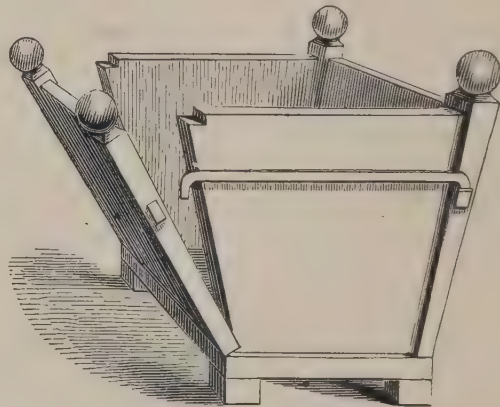


Fig. 245.—M'Intosh's Plant-box.

removing the trees, examining their roots, replacing old soil with fresh, &c. Two of the sides being hinged to the bottom, may be opened down by lifting up the iron bars; the others,

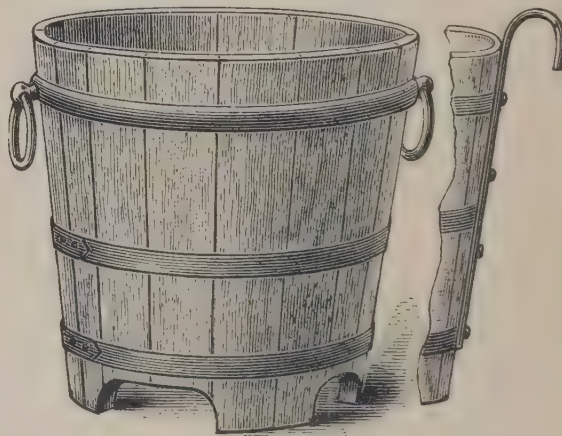


Fig. 246.—Round Tub, showing alternative form of Handles.

which are not hinged, but lift up, may then be easily removed.

Round tubs made of pine, oak, or teak, after the style of that shown in fig. 246, are best for

general purposes, as they are easily made and are portable. The handles may be either as shown in the figure, or a pair of stout iron hooks may be screwed on to serve as handles. These are very convenient when the tub has to be lifted, a pair of poles being used as lifters.

Sieves and Screens are useful in gardens for sifting earth and for screening gravel, mould, &c. Sieves with very small meshes are also used for cleaning seeds.

All sieves should be what is termed square-meshed, varying from $1\frac{1}{2}$ inch to $\frac{1}{4}$ inch. This also applies to sieves used for seeds; the size of mesh in this case goes by number.

Grindstone.—The utility of a grindstone is such that it is said to be an accompaniment of civilization into the most remote parts of the world. It is almost indispensable in a garden, for when cutting tools are not kept properly sharpened they can only be used with great disadvantage. In many cases, only half the amount of work can be performed with a blunt tool that can be done more perfectly with a sharp one in the same time and with less exertion. It would be well to have a large stone for spades, hoes, &c., and a smaller one of closer grit for fine-edged tools.

Watering-cans.—The common form of the watering-can with a straight rose, for open

provement on the ordinary type, and is much preferred on account of its strength and handiness. It is much broader than the ordinary form, the diameter exceeding the height. The large pots have a galvanized hoop round the bottom, which imparts strength and durability. Fig. 247 illustrates the various sizes and shapes, all designed on the same principle. Excellent roses are supplied with these cans, far superior to those on the ordinary rose-pot.

The 3-gallon and 4-gallon water-carriers are most useful and convenient for the purpose intended.

Ladders.—Various kinds of these are required in gardens and orchards. For wall-trees, a step-ladder, with boards for steps, is far preferable to one with rounds. The sides and steps should be made of clean well-seasoned deal, and at the top two iron spurs should be attached to the sides, for the steps to rest on when they are placed against the wall, that the trees may not be injured. The spurs, as well as the steps, should be fixed at an angle of about 85° with the sides, so that when the ladder is inclined against the wall, the steps and spurs may be horizontal. For pruning standard trees, and for gathering fruit from such, the ladder should have the sides from 2 to $2\frac{1}{2}$ feet apart at the bottom, in order that it may have a good footing sideways, for this is more necessary in ladders the tops of which have to be placed against the bending branches of trees, than in those that are placed against solid walls. An iron round near the lower end, another in the middle, and one near the top are very useful for keeping the sides from shifting out or in; the iron rounds should be shouldered against the inner part of the sides, and secured with a screw-nut on the outside. The iron round at top is sometimes made to project on each side, in order to receive the eyed ends of poles, which may be thereto attached, and secured with a pin, to form support independent of the tree. But these projections cause obstructions when the top of the ladder has to be pushed up amongst the branches. Folding-steps are occasionally useful in gardens and hot-houses. Two pairs of them, with a plank

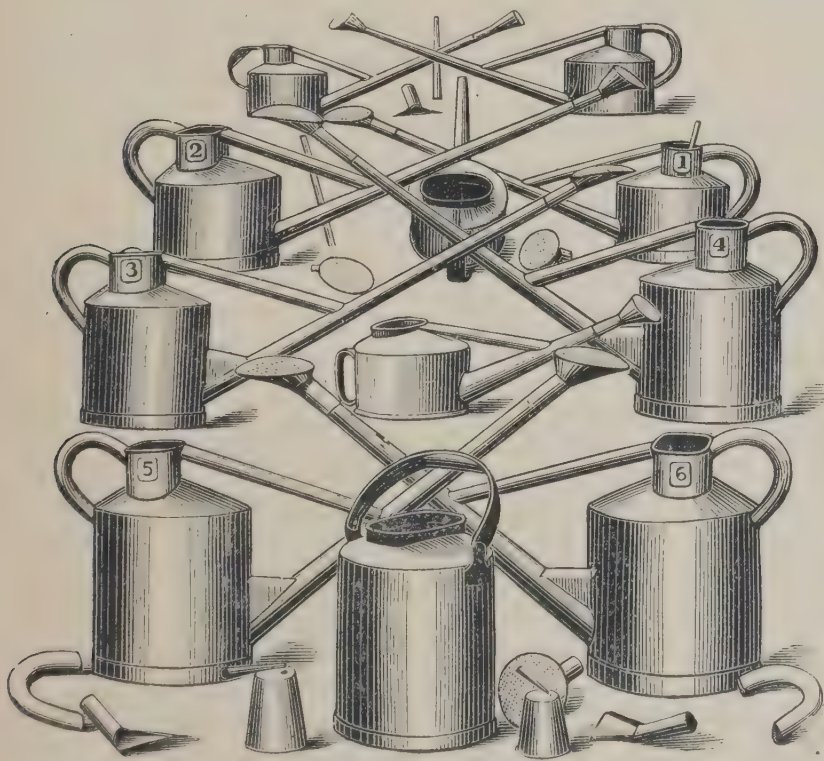


Fig. 247.—Haw's Watering-cans.

ground work, and smaller cans, with straight tubes of different lengths, but adapted for having roses either straight or bent-necked fixed upon them, will answer every purpose required of these utensils.

"Haw's Improved Watering-can" is an im-

between, may be used as a stage in summer-dressing wall-trees. Jointed ladders are required for curvilinear roofs. A piece of board is fixed across the top, to rest upon the bars, and another lower down, if necessary. Ladders have been made for orchard work with two

strong supports, connected by iron stays from one support to the other, and from the supports to each side of the ladder; it is thus rendered self-supporting. Extension ladders (fig. 248)



Fig. 248.—Heathman's Extension Ladder

are useful for work requiring a self-supporting ladder.

Packages.—A great variety of baskets, boxes, &c., may now be obtained, in many sizes, for the conveyance of garden produce. A chapter on the subject of packing flowers, plants, &c., will be found elsewhere.

VI. MISCELLANEOUS ARTICLES.

Tallies.—No mode of numbering plants can excel that in which the Arabic figures are employed; for these being the most universally known can be more easily read, and with less risk of mistake, than any other. But, in many cases, painting numbers in a manner not liable to be soon effaced by exposure to the weather, would occupy too much time, and would prove too expensive. Accordingly, marks to represent numbers are cut on wood, and these cuts remain visible till the wood gets into a state of complete decay; for although the surface of the tally must waste more or less, according to the nature of the wood, by the action of the weather,

yet, as the face wastes, the notches cut in it deepen from the same cause in an equal or even greater degree. The Arabic figures, with the exception of No. 1, cannot be quickly and well cut on wood with a knife. Nos. 4 and 7 require each a combination of three cuts, and all the others are circular in their formation, and difficult of execution. Unquestionably, the best method is that by which the numbers are represented with the fewest cuts and those most easily made. In these respects Seton's method has the advantage of various others that have been proposed. The digits are represented in



Fig. 249.

fig. 249. It will be observed that none of the units require for their formation more than two strokes, and that the whole series, from 0 to 9 inclusive, is formed by thirteen straight cuts and three notches. This cannot be done, by any other known method, with so few; and whilst this is the case, Seton's method must be considered the simplest and best. The numbers read exactly like those of the Arabic system, each additional figure increasing the previous value of the series tenfold, besides adding its own. They should be cut and read from the end of the tally placed in the ground. The use of Roman figures (I, V, X, &c.) is not uncommon in nurseries, the difficulty of making C (100) being got over by substituting a notch on the edge of the tally. Thus



For ordinary use nothing has been invented to supersede the prepared pine-wood label, slightly rubbed with white paint, and written upon with a black-lead pencil whilst wet. Some composition pencils, of which the marks on paper cannot be effectually rubbed out by india-rubber, are preferable to those of genuine plumbago. Red chalk is found to withstand the weather for many years.

The best permanent label for trees and shrubs is a slab of sheet-lead, 4 inches by 3 inches, or 3 inches by 2 inches, with about $\frac{1}{2}$ inch of one long side turned over to form a rim, below which two holes are pierced. The surface of the lead should be beaten smooth, and then the letters punched in with punch-type, obtained from an ironmonger. When printed, the letters should be filled up with white-lead, and when this is

dry the whole surface should be rubbed with an oiled rag. A little practice is required to get the letters nicely arranged. The label should be attached to the plant by means of a piece of iron wire. This label (see fig. 250) is used exclusively at Kew for all trees and shrubs in the open. A form of it is also used for labelling herbaceous and alpine plants in the rock-garden, where wooden labels large enough to be durable are unsightly. The lead label is practically indestructible, and although not cheap compared with wood, it is at least as inexpensive as the other so-called inde-



Fig. 250.—Lead Label.

structible labels.

The "Acme" cast labels (fig. 251) are made of stout zinc, with raised letters on a black ground. They are supported on stiff wire stems, or have a pair of eyes for suspending by wire or nailing to a wall. Where the lead label cannot conveniently be made, the Acme or some such permanent label should be used. These, with names printed, are only made to order. The "Imperishable Stratford Label" differs from the Acme in being made of a white metal with the raised letters in black (fig. 252).

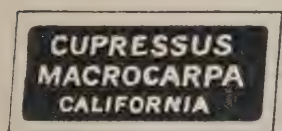
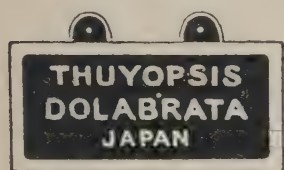


Fig. 251.
"Acme" Cast Labels.

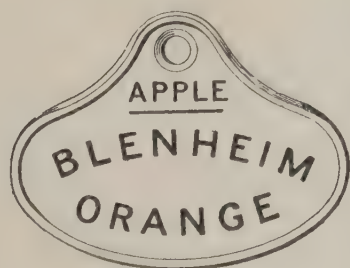


Fig. 252.—"Imperishable
Stratford Labels".

A very excellent zinc label has lately been introduced, called "The Ideal", made with stout zinc, having four holes at the corners. When fixed on the wire stems they have a neat appear-

ance. The writing on the zinc face is done with a neatly-pointed stick or quill pen dipped in acid. The face of the zinc should be rubbed bright with emery-paper before being written upon.

Parchment labels used to be very generally employed for the temporary labelling of plants, but they were soon affected by the weather—in damp weather getting into a state of pulp, and in dry weather shrivelling up. They are now superseded by a very excellent card-like label, made from what is termed "Manilla substances". Another composition label, known as the "Ivory Label", and which is of thick parchment-like substance, is now largely used for labelling pot plants, especially Orchids. It is said to be imperishable and unbreakable, and it can be written upon by either pencil or pen, the writing being indelible, except when well rubbed with soap. This label can be obtained from any dealer in horticultural sundries.

Nail Bag.—A bag or large pocket for holding nails and shreds, whilst nailing wall-trees, &c., may either be made of stout close canvas or of leather. In the latter case it sometimes contains one or two small pockets for knives. It is suspended by shoulder straps, and further secured by a belt. All this may be necessary in nailing against very high walls; but in ordinary cases, the canvas answers the purpose sufficiently well, and is at all times more pliable.

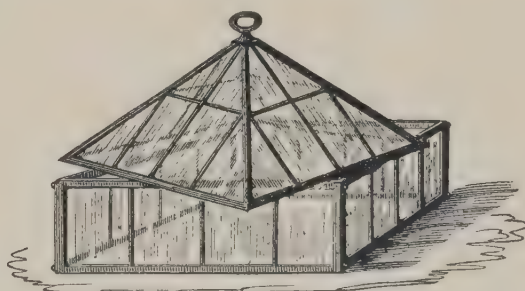


Fig. 253.—Hand-glass.

Hand-glasses are made in various shapes, their bases being generally square, hexagonal, or octagonal; but now that glass is cheap, and that sheet-glass can be obtained of sizes corresponding with those of the sides, the preference is given to hand-glasses with only four sides. The framework is usually constructed of lead, copper, or cast-iron; the latter (fig. 253), if kept painted, answers well, and is very durable and convenient; the top being movable, air can easily be given without lifting the glass or injuring the leaves of the plant in replacing it; and by placing two or three of the lower portions above each other, a protection of greater height may be formed.

Bell-glasses, of large size, are used in the open for protecting and hastening the growth of vegetables, &c. Others of less size, and made of whiter glass, are employed in propagating. The best for this purpose have a hollow knob at the top through which a hole is pierced which serves as a ventilator and prevents excess of moisture, so often the cause of "damping off" in delicate cuttings. An excellent substitute for a bell-glass is a seed-pan half-filled with soil in which cuttings or seeds are placed, the top being covered with a pane of glass large enough to fit the pan. This is easily ventilated and can be tilted slightly to prevent drip.

Cloches (fig. 254), which are so extensively employed by the French gardeners, are large bell-glasses with nearly upright sides and a knob of glass at the top to form a handle. They are made of various sizes, but those most in use are 16 inches in diameter by as much in height.

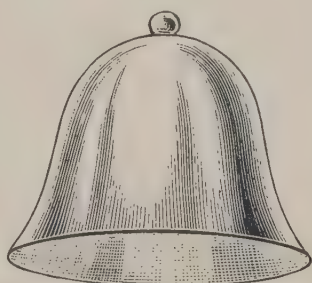


Fig. 254.—Cloche.

The *Aphis Brush* (fig. 255) is useful for removing aphides from Roses and other plants. The handle is of steel, and elastic. By the pressure of the fingers on one side, and that of the thumb on the other, the brushes are brought together upon the shoot to be cleaned, and the aphides are removed without injury to the plant.



Fig. 255.—Aphis Brush.

Tying Materials.—The one in most general use is Raffia fibre. This is obtained from the leaves of an African palm, *Raphia Ruffia*. It is a very strong soft pliable material, not unlike the old Russian bast, but far superior, although it does not last long if allowed to rest on the damp soil, or in any damp situation. It should be hung up in the driest parts of store-room to keep it in good condition ready for use. Tar string for tying trees and shrubs, securing Roses, &c., to stakes, should also be kept in stock.

Various other articles will be required in a garden, such as planks for wheeling; canvas, gauze, and nets of twine for protecting seeds and fruits from birds and other pests; wall nails and shreds, copper wire, willows for tying, mats, stakes for plants, &c. A selection of carpenter tools can be made good use of by a handy man, thereby often saving time as well as expense.

[W. S.]

CHAPTER XVII.

GARDEN STRUCTURES.

WALLS—GLASS-HOUSES, PITS, AND FRAMES—MISCELLANEOUS STRUCTURES.

It is generally understood that good bricks are the best material for a garden wall. Stone, however, answers perfectly well, and of these hard and close-grained stones are much to be preferred to such as are coarse-grained and porous. The stones should not be so large as to occasion inconvenience in training; but a difficulty of that kind may be overcome by facing the wall with a trellis of wood, or with galvanized-iron wire strained at suitable distances apart.¹ We have seen very fine fruit produced against a stone wall, and equally good against a brick one, all other circumstances being the same.

Colour.—Of all others, white reflects the greatest amount of the solar rays, and absorbs the least. A dark colour, on the contrary, reflects the least, and absorbs the most. In sunny weather a black wall becomes hotter than a white one, and plants grown against it are then excited, but they are only rendered more susceptible of a check when cold and sunless weather supervenes. Fruit-trees upon blackened walls are brought somewhat earlier into blossom, but in our climate this is not generally a desideratum; and it has been found, in the case of a tree planted one-half against a blackened wall and one-half against one of the ordinary colour, that the blossoms on the dark portion expanded sooner, but that the fruit did not ripen earlier. It may therefore be concluded that there is no material advantage to be derived from a black wall—none, in fact, that would compensate for its ugliness. As regards appearance, black is too gloomy, white too dazzling, and all glaring colours are disagreeable. Pale-coloured bricks should therefore be employed in preference to red ones. So far as colour is concerned, any material that is of a subdued tint, inclining to a light rather than to a dark shade, may be considered eligible, provided it be suitable in other respects. Stone colour is the nearest approach to white that should be chosen.

Height.—As garden walls serve as a fence, accumulate heat, afford shelter, and present a

¹ There is an objection, based on experience, to the use of galvanized wire in the near neighbourhood of large towns, but it is not known to be harmful in the country.

surface for training trees upon, these circumstances require to be considered in connection with the question of height. With regard to the first consideration, a wall 6 or 7 feet in height will answer perfectly well. As to the second condition, the higher the wall the greater is the amount of sun-heat accumulated. It is known that certain fruits that will not ripen perfectly against a low wall will do so upon a high one, and that, all things considered, the colder the climate, the higher the walls should be. In the southern counties, and in other warm situations, 10 feet may be allowed for a south wall, but a height of 12 feet is better; and in the walls on the north side, one side of which faces southwards, and consequently presents the most favourable aspect for the more delicate kinds of fruit-trees, 15 feet or more in height would certainly prove very advantageous.

Thickness.—A wall of the standard thickness of 14 inches is as substantial as need be desired in gardens, and it may be carried up to a sufficient height without the support of piers, provided the materials and workmanship are good. The next less thickness of a brick wall, as determined by the dimensions of a brick, is 9 inches; but to render a wall of this thickness secure, if more than 8 feet high, it ought to have piers.

Foundations.—Garden walls have only their own weight to support, and therefore do not require to be so deeply founded as those of an equal height in buildings where there is the additional weight of floors and roof to bear; but the foundations ought to be 3 feet deep, in order that they may not be loosened in trenching the ground, as well as to prevent the roots of trees from getting underneath them. The bottom of the trench for the foundation should be examined, and if parts are found of a softer nature than others, the bottom should be deepened and made up with concrete or other materials. Compact loam will bear a great weight without yielding, so long as it is dry or nearly so; but when wet it squeezes outwards under pressure, and the wall sinks by its own weight. If this took place equally along the whole extent of the wall, as would be the case if the stratum of loam were uniform, it would be of little consequence; but if part of the foundation is on loam and

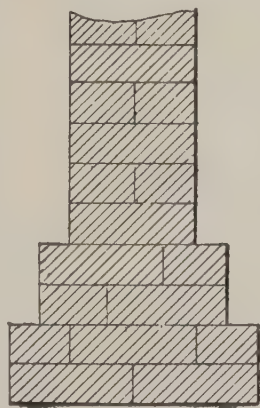


Fig. 256.

part on gravel, a rent or shake is likely to take place. The base ought to be twice the thickness of the wall, whatever that may be, and the width should be diminished, as in fig. 256, by equal steps on both sides, each step being not more than $2\frac{1}{4}$ inches wide.

Solidity.—A brick wall 14 inches thick is unobjectionable; but hollow walls of the same thickness answer exceedingly well, for they can be made so as to present exactly the same appearance, and they are both dry and strong. In a wall 100 feet in length, and 10 feet high above ground, the number of bricks required for 1000 square feet of wall surface would be, for a

14-inch solid wall, about.....	16,000
14-inch hollow wall, about.....	12,800
9-inch solid wall, with piers, about.....	11,060

It will be seen from the above that, as compared with a solid 14-inch wall, there is a considerable saving of bricks in a 14-inch hollow wall, but between this and a solid 9-inch wall with piers the difference is not much, being only about 1740 bricks. The piers, if they project much, are unsightly, as well as obstructive in training; and the shoots of fruit-trees thrive best against a plane surface unshaded by piers. These, therefore, ought to be placed on that side which presents the least favourable aspect for fruit-trees.

Construction.—Although this can only be done by practical masons and bricklayers, yet a gardener ought to know something of the principles, otherwise he would be apt to commit errors in cases where he might have to propose plans or give directions.

Stone walls upon which plants are to be trained should not be built of large blocks; if the stones were dressed so as to make each course 6 inches, that is, equal to two courses of bricks, training could be very well performed without a trellis, which a greater distance between the courses would render necessary.

The usual size of bricks is nearly 9 inches in length, $4\frac{1}{2}$ inches in breadth, and $2\frac{1}{2}$ inches in thickness. In good work, each course is exactly 3 inches deep. The arrangement of the bricks should be such as to form a bond, that is, the joints of one course should be overlaid by the bricks of the one next above it, so that no two joints of any course shall be in the same line with a joint of the next course above it. There are several varieties of bond, of which the principal are:—

English bond (fig. 257), consisting of alternate courses of headers A A and stretchers B B; this

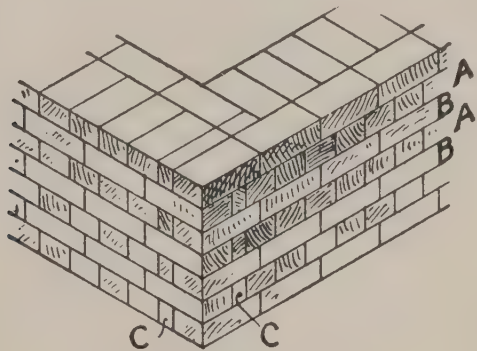


Fig. 257.—English Bond.

is the strongest form of bond, and does not provoke scamping.

Scotch bond, consisting of one course of headers to every three, four, or five courses of stretchers.

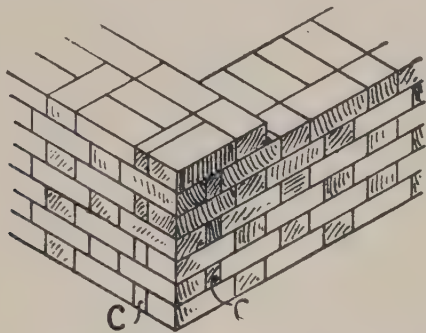


Fig. 258.—Single Flemish Bond.

Single Flemish bond (fig. 258), consisting of header and stretcher alternately in each course on one side of the wall, and of alternate courses of headers and stretchers on the other side; this bond necessitates a considerable number of half-bricks or false headers, and is deficient in strength.

Double Flemish bond, consisting of header and stretcher alternately in each course on both sides of the wall; this also is a weak kind of bond, being deficient in headers, and necessitating a great proportion of half-bricks.

A 9-inch wall can be rendered very secure by piers 1 foot 10½ inches broad, and projecting only 4½ inches from the wall. They should be 12 feet apart, and ought to be carried up to within 2 or 2½ feet of the top of the wall, and protected by a coping.

Hollow Walls.—Fig. 259 shows plan and section of an excellent form of hollow wall. It will be observed that headers and stretchers alternate, and that every fifth header on each side of the wall is a whole brick, and that the other headers are half-bricks. In the next course a stretcher must be laid across the header at s, and a full-length header from the face of the wall at n. In the third course the bricks should again be laid as in the first, or as represented in the figure; the fourth like

the second, the fifth like the first, and so on, till within a few courses of the top, and these should be solid, as represented in the section. In this way, at intervals of about 30 inches, there are 4½-inch partitions, which are solid, except where the end of the header s may not touch the opposite stretcher n.

There are other modes of constructing hollow 14-inch walls, and which are well known to builders, but they are all, we consider, inferior to the above.

Concrete may be formed of clay burned into ballast, gravel, stone, or furnace clinkers, and by packing hard materials, such as brick burrs, hard-burned lumps of clay, large stones, &c., in the centre of the concrete, a considerable economy of cement may be effected. In forming the concrete, Portland cement in the proportion of one of cement to seven of gravel or ballast is employed.

Copings.—Stone copings are perhaps the best, but they are very expensive, and there are now various cements which form excellent substitutes, for instance Portland stone cement. Good copings may also be made of glazed fire-brick, terra-cotta, or composition stone. The coping should be raised in the middle so as to allow the wet to pass off, and it ought to project

2 or 2½ inches beyond the surface of the wall on each side; a groove or throating for the drip should likewise be made in the under side of the projection. Copings are also made slanting towards the back of the wall, with a groove on the under side, so as to throw the water off. In each case the projection from the face of the wall should not exceed that already stated. Some recommend a much greater width in order to prevent radiation, and thus serve as a protection for the blossoms in spring. But there are several objections to wide permanent copings;

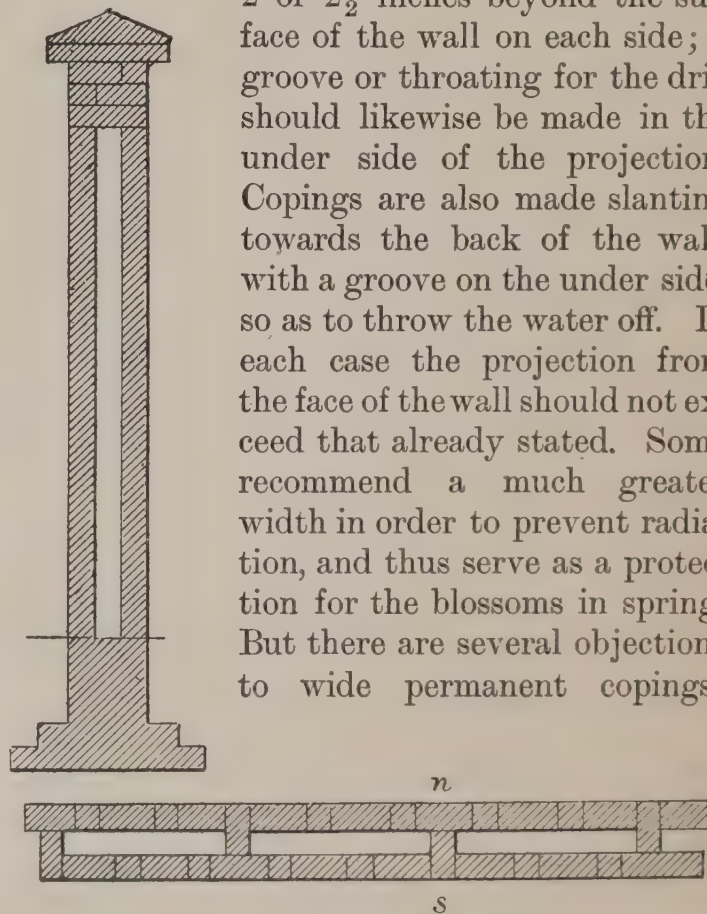


Fig. 259.—Plan and Section of Hollow Wall.

they are very expensive, unsightly, and even if they project 6 inches they would not answer so well for protection in spring as a broader tem-

porary coping; whilst in summer they would prevent the foliage from being moistened by dew, the beneficial effects of which cannot be secured by artificial watering.

Temporary copings are of great utility, especially during the prevalence of late spring frosts. The heat accumulated in the materials of the wall during the day is given off whenever the air is colder than the wall. The cold air coming in contact with the surface of the wall becomes heated, and consequently lighter; it therefore ascends, and the heat is lost, so far as vegetation is concerned. Broad copings obstruct the free ascent of warm air, which then accumulates where it is wanted, at the surface of the wall. We have seen the young shoots of vines cut off by frost as far as they had pushed beyond 9-inch coping-boards, whilst all that were under shelter of the boards were safe.

To support coping-boards, iron tubes with an internal diameter of about 1 inch, and in length 4 inches more than the thickness of the wall, should be used, so that, when inserted across, the ends would project 2 inches beyond the face of the wall. The tube should be secured by having a piece of iron fixed round its middle and built in the wall; a piece of rod-iron with an eye at top would answer the purpose, and if the cold tube were drawn through the eye when red-hot, it would afterwards remain quite tight. There should be a hole drilled through the tube horizontally about 1 inch from the end, so as to admit an iron pin about $\frac{3}{8}$ inch in diameter. A bracket should be formed with a round prong to fit into the end of the tube, where it can be secured by the iron pin being passed through a hole corresponding with that in the end of the tube, and on the brackets the coping-boards can be fixed, taking care that they fit closely to the wall, to the under side of the permanent coping, or, which is better, to both. If it should be desirable to have the coping-boards hinged, so that they may be folded up in warm weather and let down in cold, the fixed tubes will also afford eligible means of doing so, for a wooden bar can be secured to the tubes so as to fit close to the coping, and to this bar the coping-boards may be attached by hinges. These should be such as will admit of the boards being removed, and the bar left, in case it should be wanted for supporting materials for protecting the fruit from birds and wasps. The tubular fixtures will also afford facilities for extending protecting materials to a greater or less distance from the wall, for this can readily be effected by means of rods pierced with several holes and

inserted into the tubes, more or less according to the distance at which the netting or other material may be required to hang from the wall. When not otherwise occupied, wooden plugs, with neatly formed heads, should be inserted into the mouths of the tubes to keep out the wet.

Flued Walls.—These are seldom if ever built nowadays, and where they exist their use as heated walls has been generally discontinued; but good crops of various kinds of fruit have been produced on them, and in northern situations they may be employed, not only in case of frosty nights in spring, but also for ripening the wood in autumn.

II. GLASS-HOUSES, PITS, AND FRAMES.

The fundamental principles of good glass structures for the cultivation of plants are the maximum of light in winter, good ventilation, the command of sufficient artificial heat, and a waterproof roof.

The Roof.—It is well known that the rays of light, in passing through glass or any other solid transparent medium, lose much of their energy as regards their effect on vegetation. If, after passing through the glass, the rays of light have a considerable space to traverse before they reach the foliage, the latter is insufficiently acted upon, even when the glass is very transparent; and when this is not so, either from its original quality, or from not being kept clean, their effect is still further diminished; and as regards the direct solar rays, the intensity of their action depends much on the greater or less obliquity of the angle at which they impinge upon the surface of the glass. All these matters being taken into consideration, it follows that the glass should be as close to the vegetation as circumstances will permit; that it should be as transparent as possible, but more especially so if the plants are not very near it; and that it should be so placed as to form a plane, on which the sun's rays may be perpendicular at that period of the season when their greatest effect is most wanted; as, for example, when fruit that is being forced is undergoing the process of ripening.

As a general rule, houses intended for early forcing should have the glass more upright than those for later crops; and the angle of elevation should also be increased according to the latitude. If for any purpose an angle of 30° is proper in latitude 50° , then in latitude 57° an angle of 37° would be requisite.

Before proceeding further in this subject, it will be necessary to refer to fig. 260, in which the lines *a b c* comprise a quadrant or quarter of a circle, the arc of which, *a b*, is supposed to be

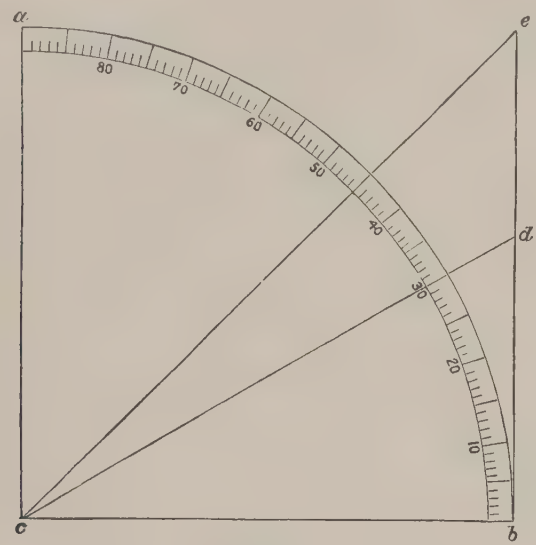


Fig. 260.

divided into 90 equal parts or degrees. Then, if *c b* represents the width of a house and *b d* the back wall, *c d*, the roof, will have an elevation of 30°. When the angle of elevation is 45°, it will be observed that the width of the house and the height of the back wall are equal, that the line of roof *c e* cuts through half the quad-

rant, and that the angles at *c* and *e* are equal; but this is not the case with any other slope of roof whatever. Many gardeners designate the slope, not according to the angle which it makes with the base, but with the back wall; whether it is the one or the other should be distinctly indicated, otherwise serious errors might be the consequence. Thus the angle *c b d* might be designated, counting from the back wall, an angle of 60°; and if this circumstance were not mentioned, a house with a roof sloping 60° from the base might be constructed, when in reality an angle of 30° with the base is meant.

As the slope of the roof is dependent on the relative dimensions of the house, and *vice versa*, the following table, which has been constructed to show by inspection the angle of elevation rendered necessary by various dimensions, will perhaps prove useful. To use it, look for the width of the house, say 15 feet, in the left-hand column, and at top for the number of feet by which the back wall exceeds the front wall in height, say 12, and where the two columns intersect will be found 38° 40', the angle of elevation corresponding with that width of house and height of back wall above the front, that is, above the eaves.

Width of House in Feet.	Height of Back Wall above Front Wall in Feet.														
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
5	21° 48'	30° 58'	38° 39'	45° 0'	50° 12'	54° 27'	58° 0'	60° 57'	63° 26'	65° 34'	67° 3'	68° 58'	71° 21'	71° 34'	
6	18 26	26 33	33 41	39 48	45 0	49 24	53 8	56 18	59 2	61 24	63 27	65 13	66 48	68 12	
7	15 56	23 12	29 44	35 32	40 36	45 0	48 49	52 7	55 0	57 32	59 45	61 42	63 26	65 0	
8	14 2	20 33	26 33	32 0	36 52	41 11	45 0	48 22	51 20	53 58	56 19	58 24	60 16	61 56	
9	12 31	18 26	23 57	29 3	33 5	37 52	41 38	45 0	48 0	50 43	53 8	55 18	57 16	59 2	
10	11 19	16 42	21 48	26 36	30 58	35 0	38 39	41 59	45 0	47 44	50 12	52 26	54 27	56 19	
11	10 18	15 15	20 0	24 26	28 36	32 28	36 2	39 17	42 16	45 0	46 50	49 46	51 51	53 45	
12	9 27	14 2	18 4	22 57	26 33	30 15	33 41	36 52	39 48	43 10	45 0	47 57	49 24	51 20	
13	8 44	13 0	17 6	21 2	24 47	28 18	31 36	34 42	37 34	40 14	42 3	45 0	47 7	49 5	
14	8 8	12 5	15 56	19 39	23 12	26 34	29 44	32 44	35 39	38 9	40 36	42 53	45 0	47 0	
15	7 35	11 17	14 55	18 26	21 48	25 1	28 4	30 58	33 41	36 15	38 40	40 55	43 0	45 0	
16	7 7	10 37	14 2	17 21	20 33	23 38	26 33	29 21	32 0	34 0	36 52	39 5	41 11	43 9	
17	6 42	10 0	13 14	16 24	19 26	22 21	25 12	27 54	30 28	32 54	35 13	37 24	39 28	41 25	
18	6 20	9 27	12 31	15 31	18 26	21 15	23 57	26 34	29 3	31 26	33 5	35 50	37 52	39 48	
19	6 0	8 58	11 53	14 44	17 31	20 14	22 50	25 21	27 46	30 4	32 16	34 23	36 23	38 17	
20	5 42	8 31	11 19	14 2	16 42	19 17	21 48	24 14	26 36	28 49	30 58	33 0	35 0	36 51	

The question now is, What are the best angles to adopt for the roofs of houses intended for forcing fruits so as to ripen them at different seasons, and for the growth of plants? It is well known that when the sun's rays fall upon glass in a perpendicular direction or nearly so, very few rays are reflected; but when they meet the surface of the glass in a very oblique or slanting direction, more rays are reflected than pass through it. According to Bouguer's table of the rays reflected from glass, of 1000, when the angle of incidence is

1°, 25 rays are reflected.	50°, 57 rays are reflected.
10, 25	60, 112
20, 25	70, 222
30, 27	80, 412
40, 34	85, 543

From this it will be perceived, that at angles of incidence from 1° to 30° the number of reflected rays is nearly the same, therefore the roof of a house may have as much as 30° higher pitch than that on which the sun's rays would fall perpendicularly, without any important diminution in the light transmitted to the interior. It is certain that any plane of glass,

inclined so as to face the south at an angle equal to that of the latitude of the place, will in the course of the whole year admit a greater number of the rays of light to pass through than would be the case at any other angle; but according to the above table, we may deviate as much as 20° higher or lower than that angle without any material difference. In other words, in latitude 54° the angle of roof may be as high as 74° or as low as 34° , without the transmission

of light being materially effected. Therefore, between these limits we may choose any angle, according as the structure is intended for dwarf or tall plants.

On the whole, it does not appear desirable to construct houses with roofs at a lower angle with the horizon than 30° for the general crop, nor higher than 40° , but for very early forcing an angle of 45° may be allowed. A simple mode of finding a standard angle for a span-

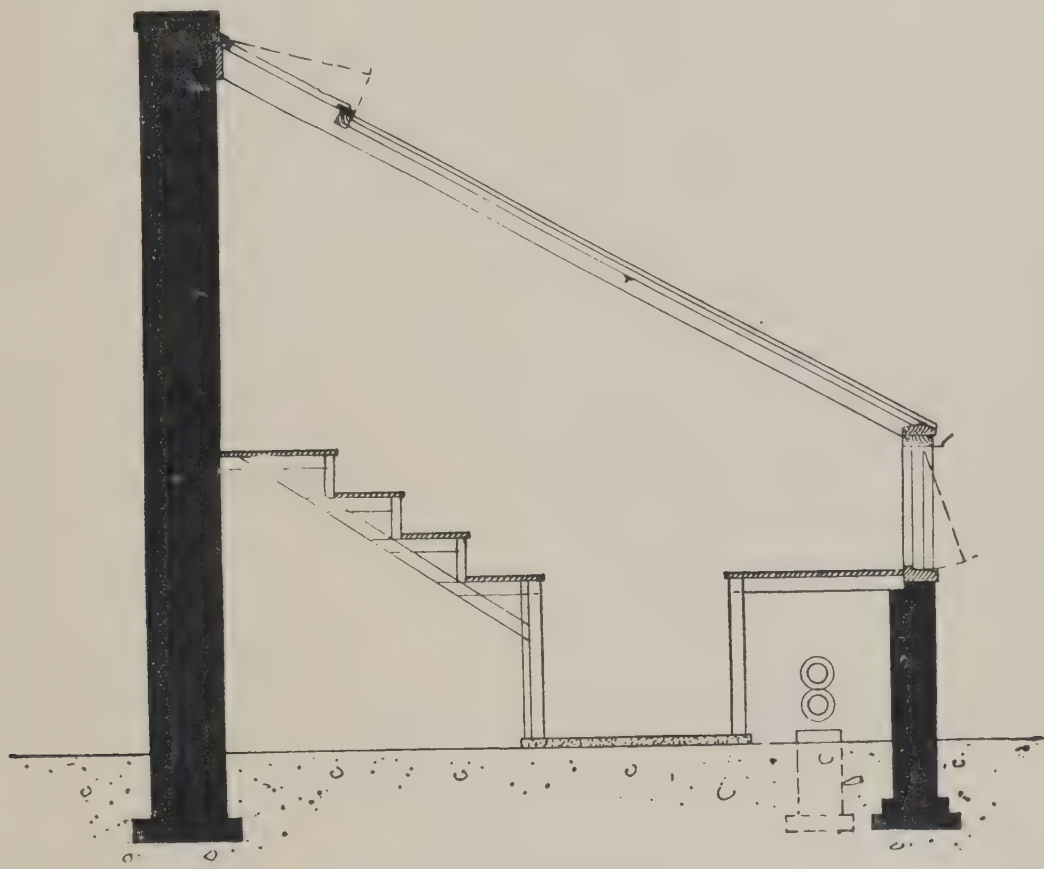


Fig. 261.—Section of Lean-to House.

roof is to raise the apex to one-third of the width, so that in a span 15 feet wide the apex (or ridge) would rise 5 feet, or in a lean-to roof 15 feet wide it would rise 10 feet from the eaves to top of back wall.

Plant Houses.—The outline of the roofs of these is either straight or curved, and again the glazed part may consist of one plane or uniform slope, in which case the house is called a *Lean-to*, or of two plane slopes in opposite directions, when it is said to be *Span-roofed*. The span-roof may either be *equal*, when both sides or slopes of the roof are of equal pitch and length, or *unequal*, when one side, usually that to the south, presents a long slope, and the other side a short one.

The *Lean-to Roof* (fig. 261) is the form that would most probably be suggested after the shelter of walls had been taken advantage of; and there is no form by which a certain amount of light can be so readily admitted, and by which an elevated temperature can be so steadily

and so economically maintained, as by this. The back wall generally faces the south, so that, whilst the glass presents a surface in the best position for receiving the rays of heat and light, the north side, from the nature of the materials, does not rapidly conduct heat from the interior, more especially when its wall is built hollow, or when it is protected to a considerable extent from wet and cold by buildings erected at the back.

Span-roofed House (fig. 262).—The number of superficial feet of glass required to cover a certain area with a span-roof is exactly the same as when the lean-to form is adopted, the angle of elevation being the same in both cases, but the extreme height of the span-roof is only half that of the lean-to. This renders span-roofed houses very advantageous for the growth of plants that are dwarf, and cannot conveniently be placed in a lean-to so near the glass as they ought to be. Another advantage is the admission of light on both sides. When the

rays of light fall chiefly on one side of a plant, it grows most to that side; but in a span-roofed house, light being admitted on both sides, equality of growth is more easily maintained. Much more fire-heat is, however, required for the span-roof than for the lean-to, especially if the house runs east and west, as in that case half the surface of the glass is exposed to the north. Accordingly the span-roofed form is employed to most advantage in such structures as conservatories, orchard-houses, and pits.

Unequal Span-roofed Houses.—As already mentioned, these generally have the longest slope facing the south, consequently they are more economical as regards fuel than the equal span, because there is less surface exposed to the north. Their great advantage consists in the extreme height of the roof being considerably decreased by the high upper angle being cut off, as in fig. 263, and thus the heated air cannot accumulate so much at that part of the house as if the roof had extended till it joined

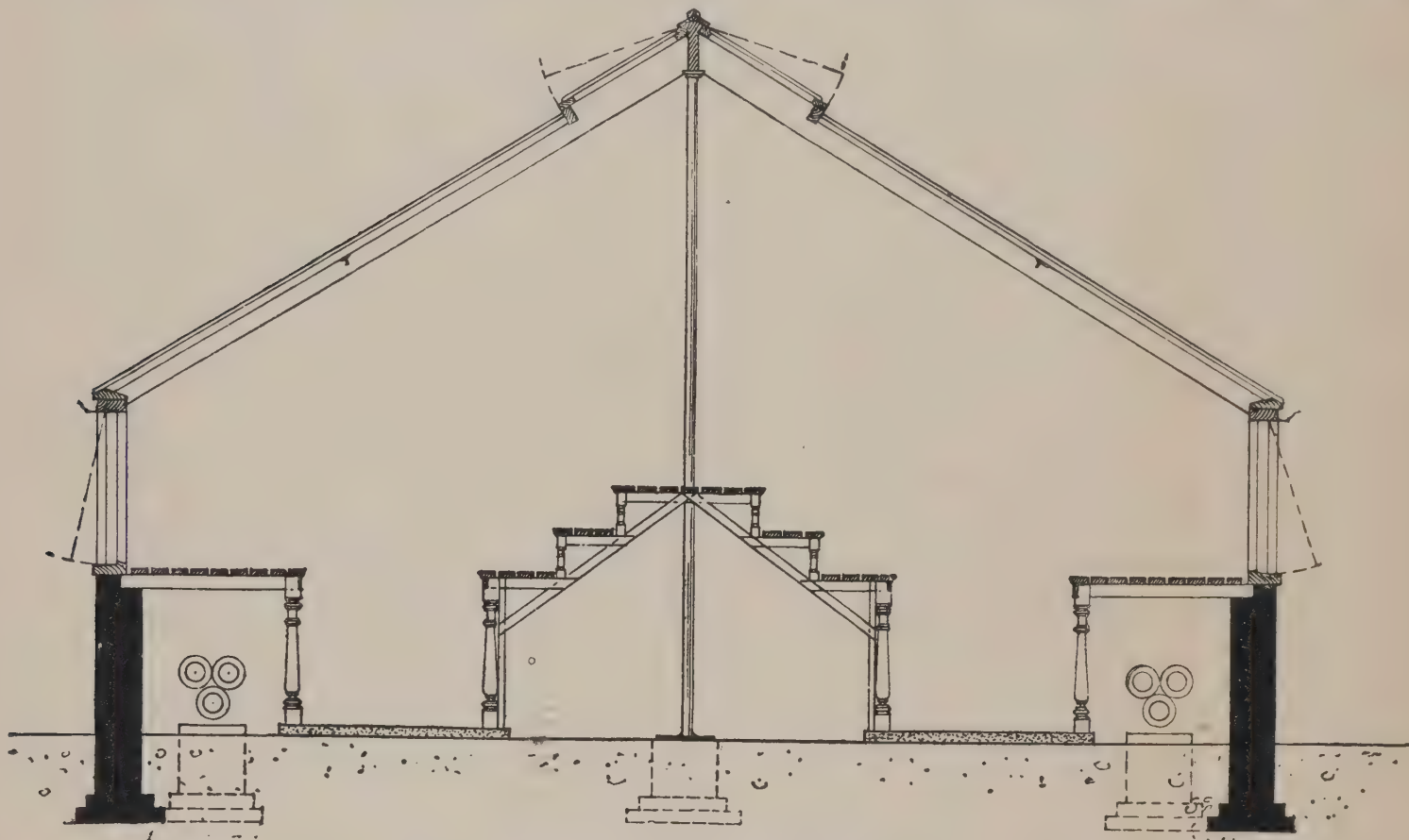


Fig. 262.—Section of Span-roofed House.

the back wall. They are more costly in construction than the lean-to, and for general purposes the latter form of house serves equally well.

Ridge-and-furrow Roofs.—In covering a certain area with glass in one plane, as in the lean-to houses, or even those with a double span, the height of the roof must be considerable, in order to throw off the wet; but by adopting the ridge-and-furrow system this object can be effected with but little elevation of roof. A conservatory, for instance, may be constructed with glazed sides all of equal height, say 10 feet, and by covering it in on the ridge-and-furrow system, it is possible to do so without raising the top of the ridges more than 18 inches higher than the sides. This appears to be the only real advantage afforded by this mode of construction. It may be observed, that the quantity of glass required to cover a certain area of base is the same, whether this is effected by one span, by a series of spans

like the ridge-and-furrow, or by a single slope like a lean-to, provided the glass in all these cases is placed at the same slope. With regard to light, it will be readily admitted that through every square foot of glass placed at the same angle, the number of transmitted rays will be the same. Now there is this difference between a ridge-and-furrow roof and one with a single slope: there is, as above stated, the same surface of glass in both if placed at the same angle, but when the sun's rays are at a right angle to one side of the ridge none of them can be so to the opposite one; whereas on a roof of a single slope, the whole of the surface is exposed to the sun's rays, so that twice the quantity of these will be transmitted into the interior of the house. In consequence of this, it can be affirmed that a ridge-and-furrow roof will be heated as much by the sun's rays as a span-roofed one, but much less so than a roof presenting one uniform slope. The latter is best for the ripening of fruits, whilst

the ridge-and-furrow roof is suitable where less intensity of solar heat is required, and in cases where, in a lean-to and even in a span-roofed house, the plants would be too distant from the glass. It should, however, be observed that ridge-and-furrow roofs are things of the past, unless a series of span-roof forcing houses, joined together at the eaves, can be called ridge-and-furrow.

Curvilinear Roofs (fig. 264).—The principal advantage which these possess is, that they can be constructed so as to admit more light than those which are on one plane. The light admitted is in proportion to the relative quantities of opaque and transparent materials used; and in a straight roof the area of surface occupied by wooden materials is much greater than when iron is employed. Again, the curvilinear iron

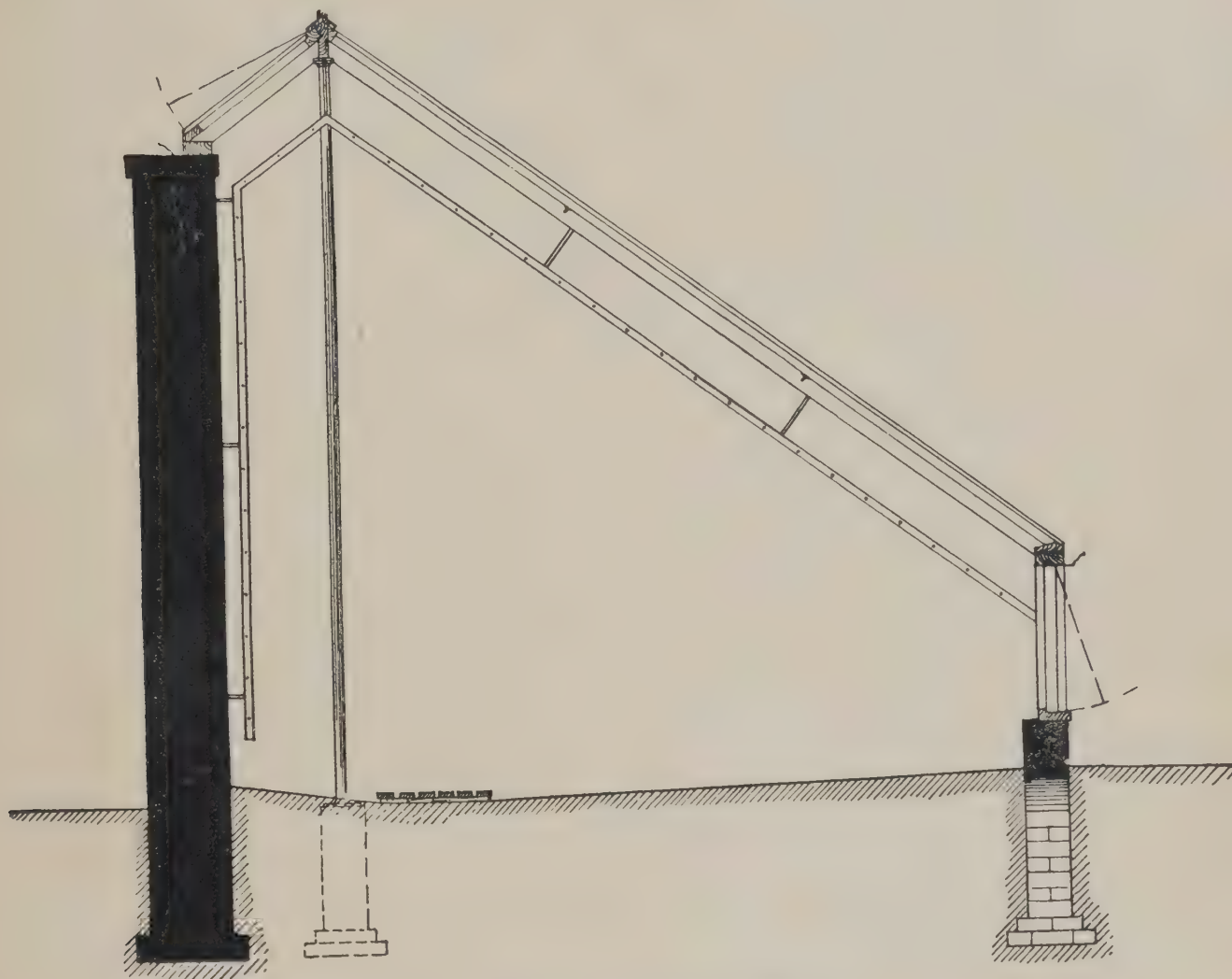


Fig. 263.—Section of Unequal Span-roofed House.

roof can be made lighter than a straight one of the same material; because, in the curved form, in order to support steadily the same weight, the bars do not require to be so thick as when they are straight. The curvilinear form is that by which the greatest amount of light can be transmitted; and in this respect it must be considered the most advantageous. On the other hand, it must be admitted, that whilst roofs of this description admit solar light and heat in greater quantity than where wood is used, yet they have the disadvantage of transmitting heat more rapidly from the interior in consequence of radiation taking place from a larger surface of glass than in a straight-roofed house of the same size, and the rapid cooling of the iron employed in their construction.

In constructing curvilinear roofs, it is desirable that they should form some segment of a sphere,

and not that of a spheroid; and the question is, What segment is the best? On referring to fig. 264 it will be observed, that if the whole quadrant abc were taken as the form, the glass near the base at a would be nearly perpendicular; whilst that at the top b would be almost flat—too much so for the rain to pass off readily. Another form was, however, proposed by Mr. Knight, and this we consider to be unobjectionable. It is represented by def , and is obtained as follows: With a radius of 25 feet describe the curve ab ; from the base cut off 35° , and from the summit 15° , as from b to e . This gives a house 14 feet wide and $10\frac{1}{2}$ feet high above the brickwork; and such a structure might be used either for forcing Grapes and Peaches, or as a plant-stove.

In some cases the bars for curvilinear houses have been made of a uniform size; but although these have been found to answer well for forty

years, and at the end of that time be substantial, yet we think cast-iron ribs at every 12 feet are preferable, and such can now be made strong, light, and elegant. To these purlins can be

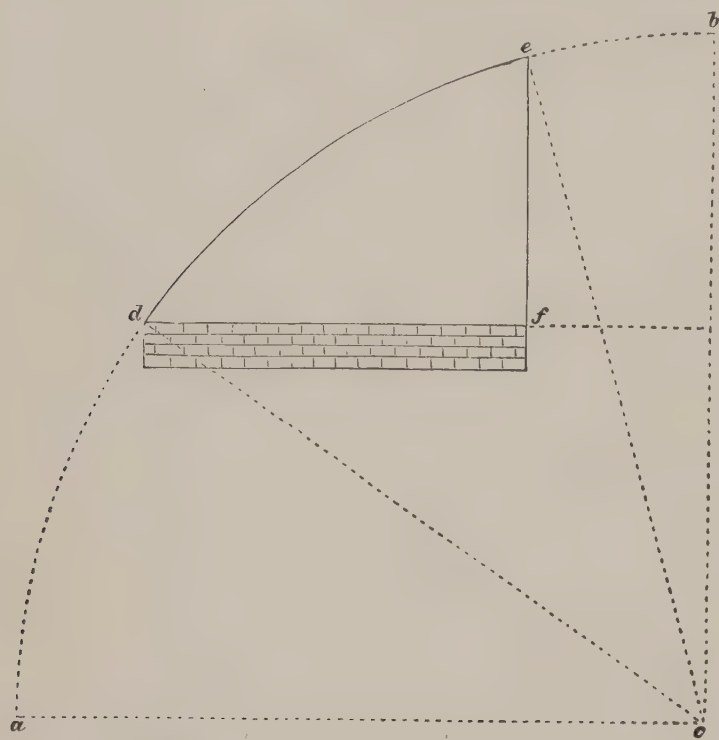


Fig. 264.—Section showing principle of Knight's Curvilinear House.

secured, and then the intermediate bars for the glass need not be so strong as would otherwise be requisite.

Frames.—These are usually made of deal boards $1\frac{1}{4}$ inch thick. Their dimensions are variable; but the larger they are the less materials are required in proportion to the internal area. Thus, supposing the depth to be the same in both cases—say 12 inches—a frame 3 feet by 4 feet would require for the sides and ends 14 square feet of board, the space inside being only 12 square feet; whilst a frame 8 feet by 6 feet would require 28 feet for sides and ends, and the area enclosed would be 48 square feet: hence the larger, with only *twice* the quantity of materials for what is called the box of the frame, contains *four* times the space. It may also be remarked that the small and large frame both require the same amount of labour as regards the joining of the sides and ends. These are usually dovetailed; but Mr. Atkinson had frames made with ends projecting beyond the front board, and in the external angles thus formed, as well as in the internal ones, triangular pieces of wood were fitted, and to these the sides and ends were nailed. In this way the box of a frame can be put together without dovetailing, and by almost any person. These upright corner-pieces are also well adapted for taking the bearing of the frame when placed on posts or other supports.

Pits (fig. 265).—The great utility of these

structures is well known. In their simplest form, without artificial heat, they are useful for protecting many kinds of plants, which would either be killed or much injured by exposure to the open air in winter; and even in summer this kind of pit affords the most convenient means of sheltering delicate plants from heavy rain and scorching sun. With heat at command, pits are available for purposes of propagation, nursing for larger structures, and forcing vegetables, flowers, and fruit. Before large structures are built, pits should receive consideration, for without them a good stock of plants cannot be brought forward. They are constructed in many different ways. Fig. 265 represents two useful forms of pits, which may be employed for almost any purpose. Modifications of these may be used as lean-to frames against a wall or the front of a plant-house, and heated according to requirements. For general purposes two rows of 3-inch pipes on each side are ample for the Span-roofed frame, and two rows in front for the Lean-to.

Propagating Pit (fig. 266).—This is usually built so that the plants may be near the light; the path, therefore, is best in the middle; and there should be a good command of bottom-heat under the bed of plunging materials. The pit is 11 feet wide, and 8 feet high from the path

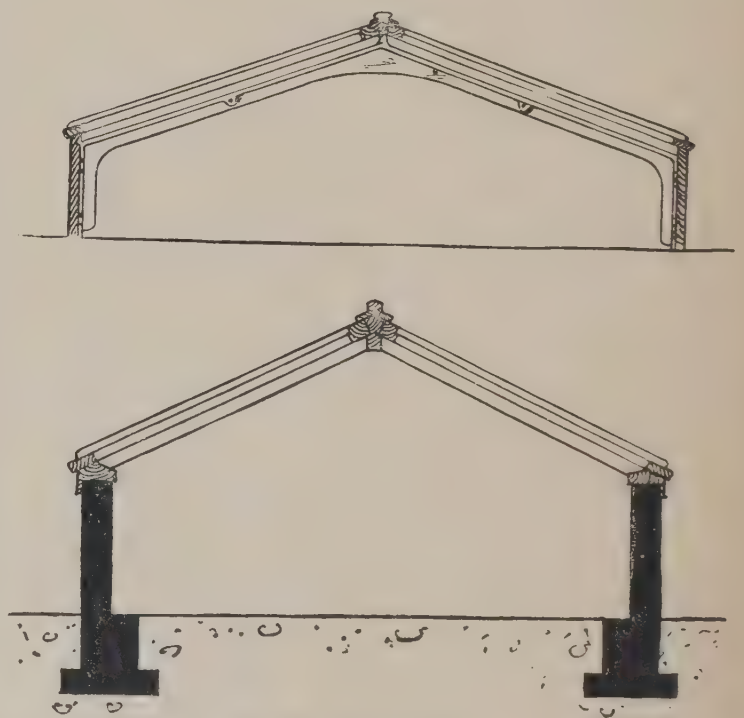


Fig. 265.—Sections of Pits.

to the upper angle of the roof; and the path is 3 feet wide. There are two beds 4 feet wide, one on each side of the path, for plunging materials, ashes, tan, sand, or cocoa-nut fibre; and each has one flow and one return pipe in a chamber to afford bottom-heat, and two on each side for top-heat; so that a high top and

bottom heat will be perfectly at command. There should also be openings in the walls of the chamber, to be closed by plugs or other means, so that heat can be permitted to ascend from the chambers into the atmosphere of the house, or can be confined to the chambers at will. It is also desirable to have troughs for water either cast with the pipes or fixed on to

which the sun's rays are not so intense as they are when they strike upon objects freely exposed. There is, of course, an exception to this when the glass is not plane, for the rays would be more or less concentrated by convexities; but we may rest assured that healthy vines will not be injured by the sun's rays passing through plane glass, if sufficient ventilation is afforded.

The size of a Vinery must be determined in a great measure by the means at command, not only as regards the first cost of erection, but also that of future keeping and management. We have seen a considerable amount of produce in a very small house, not more than 10 feet long and scarcely so much in breadth, and in such a space it is possible to ripen well 50 lbs. of Grapes, and even more than that with good management. With ample means, on the contrary, the length may extend to hundreds of feet in one range; but the range ought to be divided by glazed partitions, and in very few cases should the divisions exceed 50 feet in length. By means of these divisions we can give the proper treatment to early or late

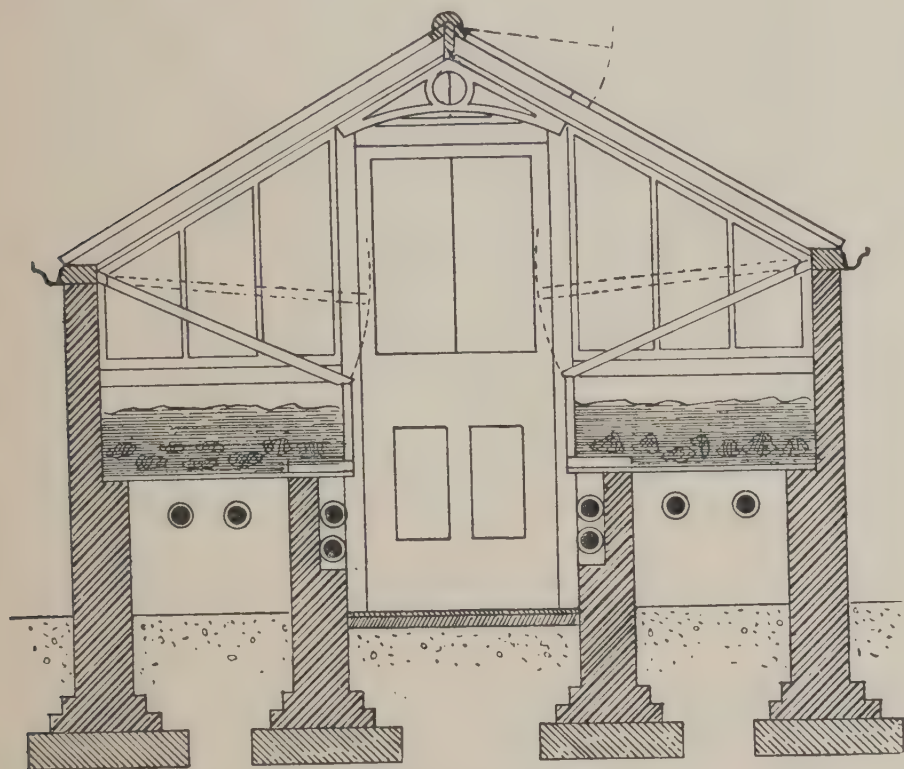


Fig. 266.—Section of Propagating Pit.

them, so that the air inside the chamber can be kept moist. Fig. 266 shows propagating frames, which are generally fixed on a bed or shelf at one end of the house.

Vineries (figs. 267 and 268).—The Vine, from the flexible nature of its rods, can be trained in any direction, whether parallel with the glass or not, and either upwards, downwards, obliquely, or horizontally; and in any of these ways good crops may be obtained, provided the foliage is not too far from the glass. As a good border is generally afforded, the length of shoot made in a season is considerable; and if the Vinery is of limited extent that form is the best which admits of the greatest length of shoot being trained so as to enjoy the greatest amount of light, and as nearly as possible an equal degree of temperature as regards the bottom and top of the plant.

Vineries are generally, and we think most properly, built so that their front may present a southern aspect; either one directly south, or inclined to the south-west, in order to be acted on with the greatest possible effect by the sun's rays. Doubtless some will object to this on account of scorching; but even the purest glass acts more or less as a screen, in passing through

crops, as well as to kinds requiring much or comparatively little heat. The width need not exceed 15 feet, and this will admit of nearly 20 feet of training.

The height of the front wall is the next consideration. Where there are no upright front sashes, the front wall should not be more than 1 foot above the level of the border, making allowance for this being raised above the general level of the surrounding area. If there are front sashes, they should not be high, otherwise the extent of surface for training the rods of the Vines is diminished. The height of the back wall depends entirely upon the width of the house and the angle which the roof is to form with the horizon. This should be considered with reference to what has been stated on that subject; it may be from 30° to 34° for the general crop in the south of England and near London, and a degree more for every degree of latitude farther north. For very early forcing it may be 40° .

The Span-roof answers best for late Grapes: not that span-roofed houses are the best for late Grapes under all circumstances, but this form is better for them than for those requiring to be forced. As a rule, whatever may be its form,

the best Grapes have been obtained from medium-sized houses, and such as have the front sashes not more than from 2 to 3 feet high.

In cold and wet districts the form best adapted for all purposes is the lean-to. At Lambton Castle, near Durham, both early and late houses are of this form. In wet districts of the north of England and Scotland Vineries are often built on the lean-to system; and very far north,

splendid Muscats as regards both finish and flavour have been produced in them, the fine golden colour being obtained by exposing the branches to sunlight.

Second only in importance to the form of the Vinery is the arrangement of the hot-water pipes. The earliest Vineries ought to be furnished with a sufficient quantity of piping to maintain a minimum temperature of 70° in a

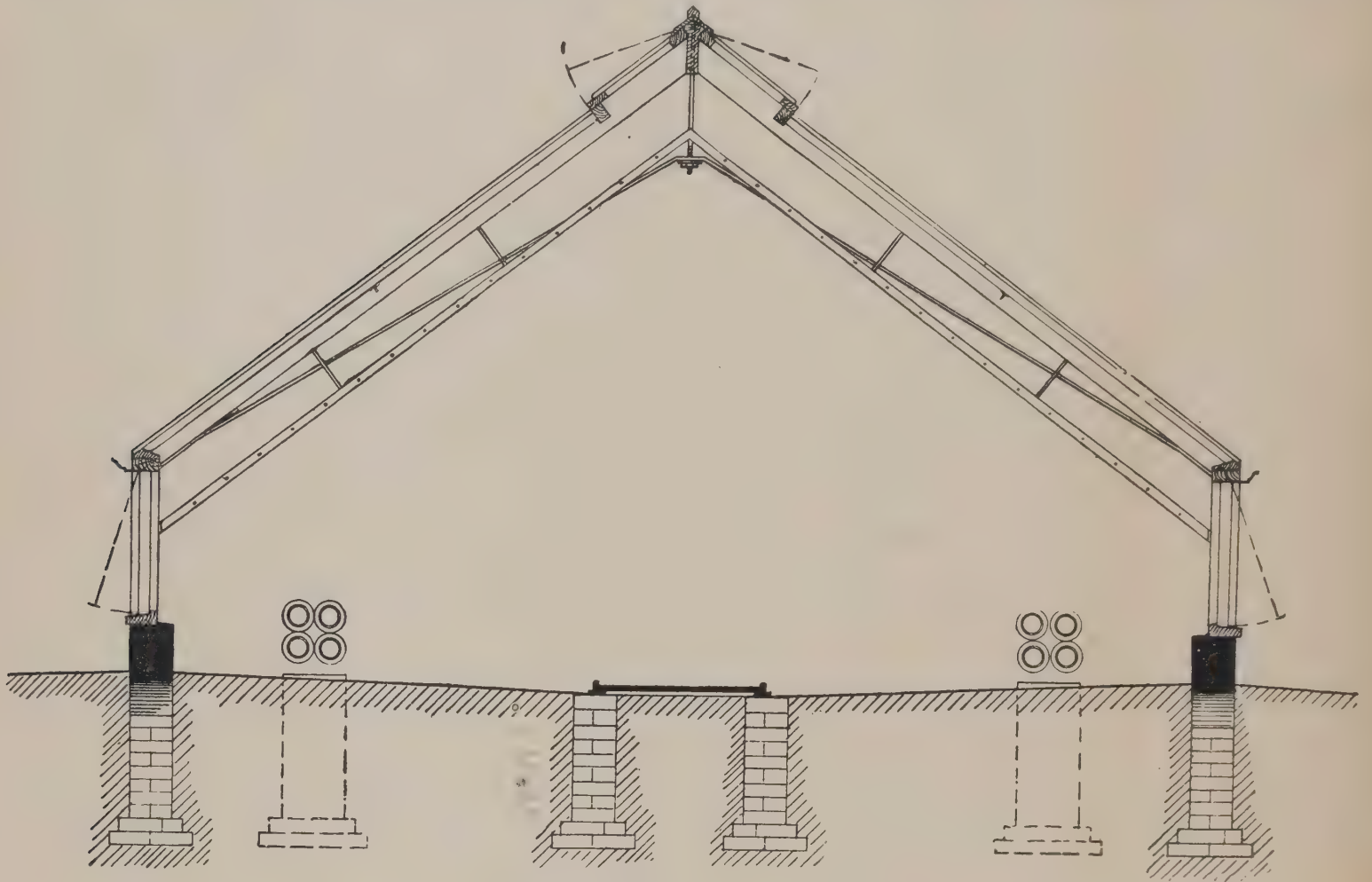


Fig. 267.—Section of Vinery (Span-roof).

severe frost, without making the pipes hotter than will allow of the hand being held upon them. A house 16 feet wide requires six rows of 4-inch pipes. On each of the flow-pipes there should be a trough to hold water. The pipes must also be arranged so that the heat is well diffused. The best arrangement is to have four rows near the front of the house, about 2 feet from the front wall. The other two rows should be near the back wall.

The Vineries erected at Clovenfords by Mr. W. Thomson, one of our best Grape-growers, were constructed with a due regard to economy combined with efficiency. A cross section of one of these houses would represent an inverted letter V, the roof being an equal span with a rather sharp angle, and the slope being continued nearly down to the ground, a low up-right sash on each side being introduced for ventilation, and other ventilators being provided in the ridge of the roof. The circulation of air

is therefore perfect, while the whole system of ventilation may be opened and shut in a few minutes by means of machinery. The houses are each 200 feet long, 24 feet wide, 16 feet high in the centre, and about 3 feet at the sides. They are intended for growing late Grapes to supply the market.

These houses are constructed without any central supports, but with cross tie-rods near the apex. The borders are partly inside and partly out. To prevent the undue compression of the former, a trellised footway is laid down along the centre. To facilitate the work of thinning the berries, which is a most tedious but important operation, two broad battens are laid down, one towards each side of the house, and on these a stage is made to travel by means of four flanged wheels. It would be well if some similar contrivance were more generally adopted, especially in all large Vineries.

Peach-houses.—Formerly Peach-houses were

constructed very narrow, the glass being nearly upright, and it was necessary that they should be so, otherwise the trees, which were generally planted against the back wall, would have been too far from the light. Now, however, in first-rate houses they are planted in front and trained to a trellis, about 1 foot from the glass, and

parallel to it; so that all parts of the tree, so far as the trellis extends, enjoy an equal share of light, and the width of the house does not require to be so limited. A lean-to house (see fig. 268) having a width of 12 feet, and about 10 feet height of back wall, will give a length of 15 feet for training. This is quite enough of

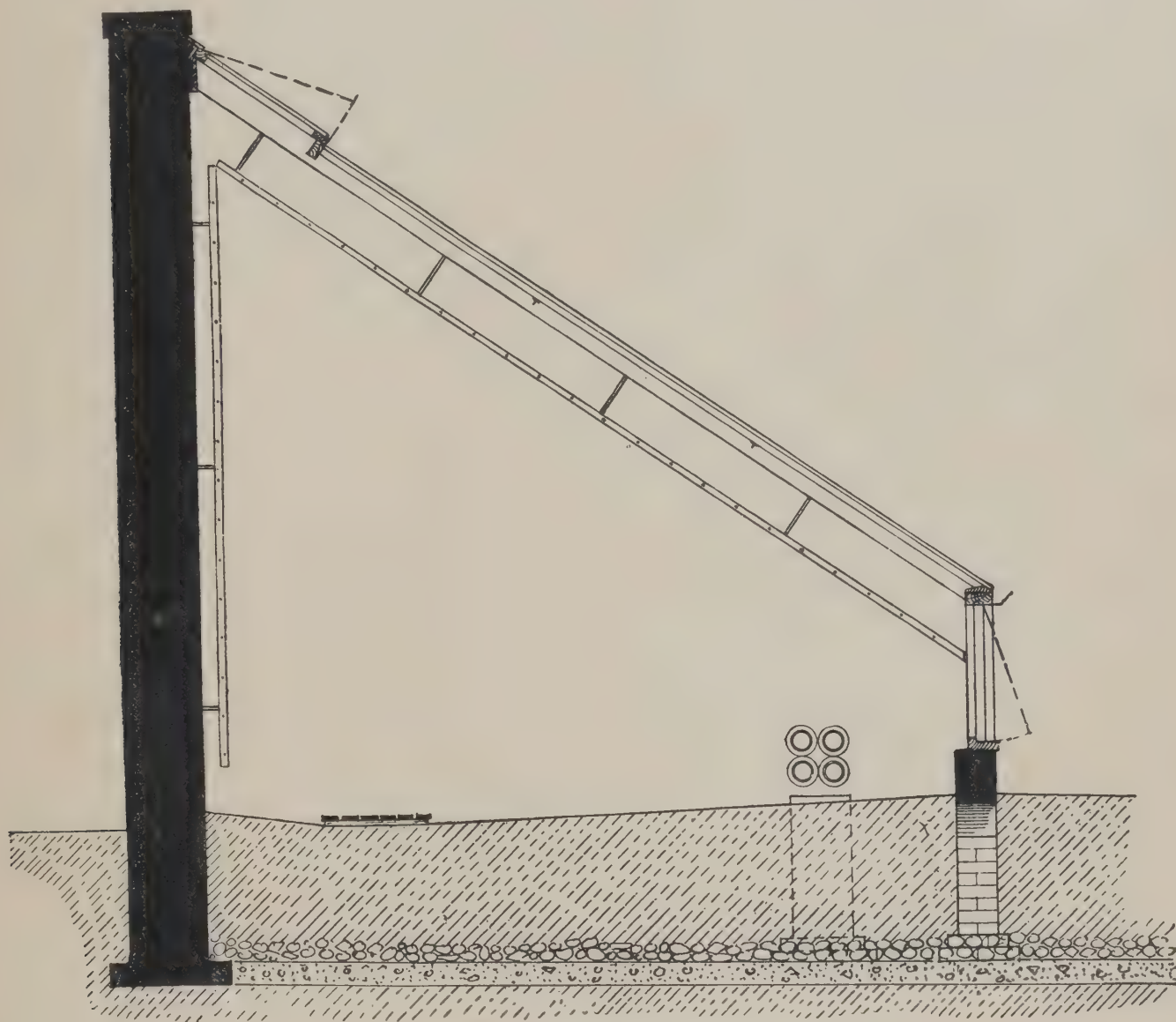


Fig. 268.—Section of Vinery (Lean-to).

extension for the branches of a vigorous tree, and several years must elapse before the whole of the trellis can be covered.

For very early forcing, the trees ought to be planted inside; accordingly the front wall of a Peach-house should be on arches, in order that, if planted inside, the roots may have liberty to extend outwards; and the glass should reach as near the ground as possible, whether by the continuous slope of the roof or by upright front lights.

Cherry-houses.—The form of structure most suitable for forcing Cherries depends on whether the trees are planted against the back wall or in pots. In the former case, the house should be narrow, in order that the branches and leaves of the tree may have the advantage of being near the glass. If the trees are in pots, a wider house

will be more economical, as it will, as compared with a house of narrow form, contain more plants under the same extent of glass.

Whatever may be the form of the house, ample ventilation should be provided, for the Cherry requires abundance of air at all times, and more especially at the blossoming season. As it is not necessary to keep the temperature so high as for Vines and Peaches, the difference of expense for heating a span-roofed house for Cherries, as compared with that of a lean-to, will not be great; and as houses constructed in the former manner admit light on all sides, they may be considered very proper for forcing Cherry-trees in pots. To afford head-room over the whole area, the house should be constructed with upright sashes 4 feet high, and these ought to be hinged or made to slide past each other, so

as to give ample means of ventilation. Plums and Apricots may be forced in the same house with Cherries, or in a separate one of similar construction.

Fig-houses.—A narrow lean-to, with a flow and return hot-water pipe, answers very well for fig-trees trained against a wall. A span-roofed house, such as that above mentioned for Cherries, will be proper for the pot culture of this fruit; or in such a house Fig-trees may be planted out in a border having a chalky subsoil, either natural or artificial.

Strawberry-houses.—Fig. 269 is a representation of a structure designed by the late Mr. Ingram, gardener at Belvoir Castle, for the

time kept cool by the shade of the plate. This of itself tends to keep the soil about the roots moist, an important point in Strawberry forcing, independently of other means which may be employed with the same object. The house figured is 8 feet high at back, 5 feet wide at base, and the front boards 15 inches high, but these dimensions are not material to the principle of the invention, as such houses may be made either in the span-roofed or lean-to form, and when not occupied by Strawberries they will be found well adapted for growing many kinds of plants.

Greenhouses and Conservatories.—In size and form these are exceedingly variable. In many cases they are constructed so as to harmonize

with the architectural style of the mansion; but in others they are merely useful unpretentious structures. Formerly they were built with upright glass in front, no light being admitted by the roof, back, or ends, and even much of the frontage was occupied with architecture too massive to permit sufficient light to reach the plants; but such as it was the plants inclined towards it, and as a consequence their growth became what is termed one-sided. The importance of light as an agent in promoting vegetation has of late years become better understood, and great improvements have consequently been made in the construction of greenhouses and conservatories.

The lean-to form (fig. 261) is very generally adopted in the case of small greenhouses, advantage being taken of a wall already built. In such houses plants may be grown very well, but not so symmetrically as in span-roofed structures, or others that admit light on all sides. This, and means for the admission of plenty of air, should be the aim in all greenhouses and conservatories; and, keeping these requirements in view, any form may be adopted that the circumstances of the case may render pleasing or convenient.

A useful span-roofed house is represented in fig. 262. By the addition of more hot-water pipes than are here shown, this house would serve as an intermediate house or stove. It is the form of house preferred for the cultivation of the larger orchids, such as Cattleyas.

Fig. 270 (page 209) represents a conservatory which is fairly well adapted for the growth of plants, and, on the whole, is in good taste.

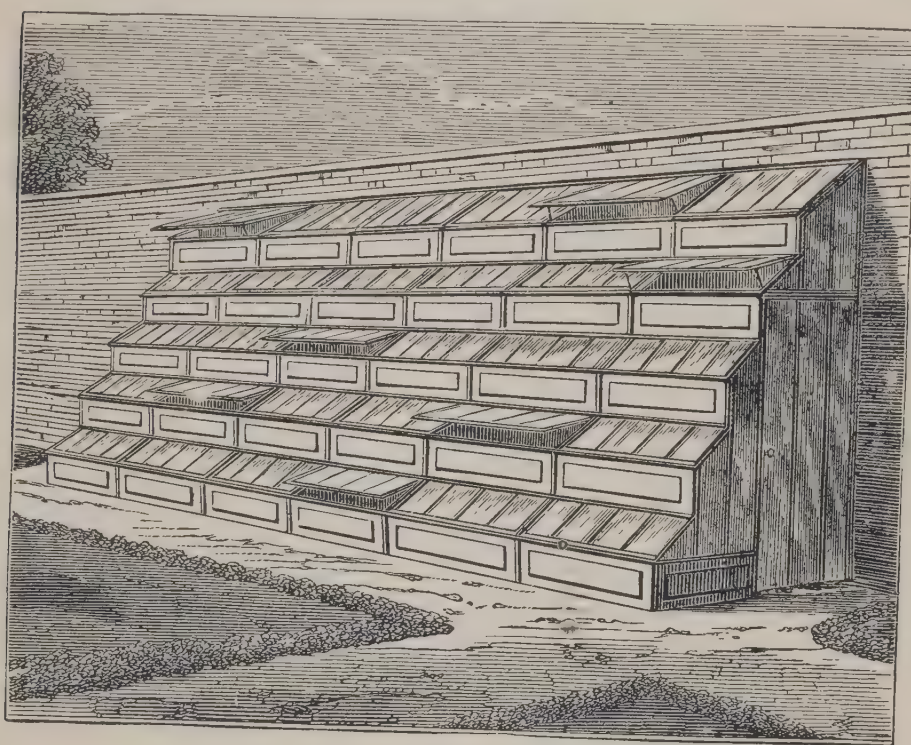
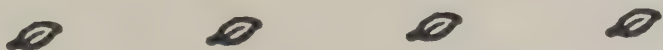


Fig. 269.—Ingram's Strawberry House.

cultivation of Strawberries under glass. In ordinary circumstances the plants have to be forced on shelves in Vineries and other houses, where it is often difficult to secure the conditions necessary for the perfection of the Strawberry crop, without injury to the legitimate occupants of the house. It was to obviate this difficulty that Mr. Ingram devised a structure which affords every requisite for successfully forcing the Strawberry. In it not only are the plants kept near the glass, but the pots are shaded, and the roots consequently kept cool, whilst air can be freely admitted at all times. Mr. Ingram states that he was led to the idea of constructing his Strawberry-house in the form represented, from observing that Strawberries always succeed well on shelves in the front of lean-to houses close to where the roof-lights rest on the front supporting plate, and where a little air constantly enters, the pots being at the same

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